



The Use of Decision Models in the Development of a Collaborative Integrated Solutions System

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FOR THE COMMANDER

//SIGNED//

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Acronyms

ACC	Air Combat Command
ACCI	Air Combat Command Instruction
ACCSUP	Air Combat Command Supplement
AFB	Air Force Base
AFI	Air Force Instruction
AFLMA	Air Force Logistics Management Agency
AFRL/HEAL	Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Readiness Research Division, Logistics Readiness
AMU	Aircraft Maintenance Unit
AWM	Awaiting Maintenance
AWP	Awaiting Parts
BAI	Backup Aircraft Inventory
BSC	Balanced Scorecard
BSCoI	Balanced Scorecard Collaborative
CAMS	Core Automated Maintenance System
CANN	Cannibalization
CDRL	Contract Data Requirements List
CELDi	Center for Engineering Logistics and Distribution
CFRS	Computerized Fault Reporting System
CND	Cannot Duplicate
DD	Deferred discrepancies
EEO	Equal Employment Opportunity
ERP	Enterprise Resource Planning
FCF	Functional Check Flight
FMC	Fully Mission Capable
FOD	Foreign Object Damage

GUI	Graphical User Interface
HOF	Health of Fleet
ICT	Integrated Combat Turn
IG	Inspector General
ISO	Isochronal Inspection
LOA	Logistics Officer Association
LRU	Line Replaceable Unit
MAJCOM	Major Command
MC	Mission Capable
MICAP	Mission Impaired Capability Awaiting Parts
MMIS	Maintenance Management Information and System
MSE	Maintenance Scheduling Effectiveness
MX	Maintenance
MXS	Maintenance Squadron
NMC	Not Mission Capable
OLTP	Online Transaction Processing
OPS	Operations
PAI	Primary Aircraft Inventory
PE	Professional Engineer
PhD	Philosophiae Doctor (doctor of philosophy)
PMC	Partially Mission Capable
PMCM	Partially Mission Capable Maintenance
REMIS	Reliability and Maintainability Information System
RR	Repeat Recur
TCI	Time Change Item
TCTO	Time Compliance Technical Order
TICARRS	Tactical Interim CAMS/REMIS Reporting System

TNMC	Totally Not Mission Capable
TNMCM	Totally Not Mission Capable Maintenance
TNMCS	Totally Not Mission Capable Supply
USAF	United States Air Force
UTE	Utilization Rate

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1 Executive Summary

The Logistics Readiness Program supports the Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Readiness Research Division, Logistics Readiness Branch (AFRL/HEAL) through the conduct of logistics research studies that leverage the expertise of the academic community. This research is the product of a collaborative project conducted by personnel at AFRL/HEAL and the University of Arkansas. The AFRL/HEAL identified a need to have a strategically aligned performance measurement system for flightline maintenance (MX) activities. This system must account for the entire flightline MX process in order to improve the performance of aircraft scheduling and achievement of mission objectives. The primary project activities were:

- ◆ Identification of a strategically aligned performance measurement system
- ◆ Research into that system's development and implementation process
- ◆ Investigation of current flightline MX processes
- ◆ Production of associated development guidelines
- ◆ Validation of these guidelines through a case application
- ◆ Investigation of software implementations

The review of the performance measurement literature resulted in the selection of the Kaplan and Norton Balanced Scorecard (BSC) as the appropriate measurement system for the flightline MX process. Production of the BSC development guidelines required in-depth analysis of the traditional BSC development process and the current flightline MX process through documentation review and site visits. The guidelines prescribe the process from selection of both a target organization and development team to the classification of measures and families to the production of a viable BSC.

The BSC development guidelines were followed to construct a preliminary flightline MX BSC. This was done to validate the development guidelines to ensure practical implementation. The resulting BSC was validated through administration of a questionnaire to United States Air Force (USAF) logistics personnel.

It was determined that a review of existing BSC software packages would benefit eventual implementation of the BSC. A review of the three most prominent BSC software packages was conducted based upon industry standards for such packages.

The scope of project is the flightline MX process. The flightline MX process is the inspection and service process that takes place from the time an aircraft lands through all the activities necessary to recover the aircraft and prepare it to successfully complete another mission. Thorough knowledge of this process was required to determine the relevant performance measures, understand why the measures behave as they do, and indicate reasons why these measures fall outside acceptable parameters. Maintenance leaders are primarily concerned with knowing how well the unit is meeting mission requirements, improving equipment performance, identifying support problems, and projecting current trends (AFLMA, 2001). Maintenance performance is generally assessed using standards, goals, and maintenance plans.

Kaplan and Norton (1996) introduced the BSC in the early 1990s. The BSC was introduced in an attempt to reconcile problems in traditional management strategies that overemphasize financial measures at the expense of progress and growth. This performance management system allows organizations to clarify their strategy and assure that every aspect of operations is directed toward the success of these goals (Balanced Scorecard Basics, 2003). When considering important measures all at once, as suggested by the BSC, management can detect whether one area is improving at the expense of another area (Kaplan and Norton, 1996).

The BSC development process is one that requires thorough knowledge about internal operating procedures and a comprehensive understanding of the system being studied. It was determined that detailed guidelines for the BSC methodology would be valuable to facilitate the development of BSCs for flightline MX personnel. These guidelines assure that every step is followed by dividing the BSC development process into three stages, Groundwork, Design, and Finalization, each comprised of multiple steps. The stages and steps of the BSC Development Guide are listed below:

- ◆ Groundwork Stage
 - Team Selection
 - Strategic Framework
 - Mission Statement
 - Core Values
 - Vision Statement
 - Data Collection
 - Process Data
 - Strategic Data
 - Reference Materials

- ◆ Design Stage
 - Goal Development
 - Objectives Identification
 - Perspectives Determination
 - Performance Measure Identification
 - Measure to Family Assignment

- ◆ Finalization Stage
 - Measure Assignment to the BSC
 - Correlation Determination
 - Measure Finalization
 - Ownership Assignment
 - Scorecard Cascade
 - Review and Revise

A case study is presented that describes the process undertaken by our team to validate and exemplify the BSC Development Guide through the development of a preliminary BSC for flightline MX activities within an Aircraft Maintenance Unit (AMU). The preliminary BSC consists of the following four perspectives and measures:

- ◆ Mission Perspective
 - Maintenance hours per flying hour
 - Mission-Capable (MC) rate
 - Partially Mission-Capable Maintenance (PMCM)
 - Sorties flown
 - Totally Not Mission-Capable Maintenance (TNMCM)

- ◆ Influencing Factors Perspective
 - Cannibalization (CANN) rate
 - Mission-Impaired Capability Awaiting Parts (MICAP) fill rates
 - Maintenance Scheduling Effectiveness
 - Totally Not Mission-Capable Supply (TNMCS)

◆ Management Perspective

- Adherence to Operations (OPS)/Maintenance Squadron (MXS) schedule
- Deferred Discrepancies (DD) rate Awaiting Maintenance (AWM)
- Total maintenance deviations
- 4-hour fix rate
- 8-hour fix rate
- 12-hour fix rate
- Days in Phase/Isochronal Inspection (ISO)

◆ Internal Enhancement Perspective

- Cannot Duplicate (CND) rate
- Repeat-Recur (RR) rate
- Special Experience Identifiers
- Total abort rate
- Training schedule adherence
- Upgrade Training
- Unit average technical skill level

An anonymous questionnaire was developed to elicit the expertise of logistics personnel in ranking the criticality of the measures on the preliminary BSC. The questionnaire was completed by attendees of the 2003 Logistics Officer Association (LOA) National Conference. Twenty-six viable questionnaires were collected and analyzed. A count of the number of times each perspective and each measure within each perspective was assigned a particular ranking was computed. The corresponding percentage represented the number of times each perspective or measure was given that ranking out of the total number of questionnaires.

The results indicate that the mission perspective is the most critical perspective with the management perspective ranked as the next most critical. The respondents indicate that the least critical perspective is internal enhancement perspective. Within the mission perspective, MC rate and PMCM are the most and least critical measures respectively. The MICAP fill rate is ranked as the most critical measure within the influencing factors perspective. Within the management perspective, the adherence to OPS/MXS schedule is the most critical measure, and the least critical measures are DD rate AWM and 4-hour fix rate. The CND rate, RR rate, upgrade training, and unit average technical skill level are the most critical measures within the internal enhancement perspective.

In addition to the comprehensive results of the respondents as a whole, the results were categorized by respondent job function level, specifically group-level maintenance supervision/staff and squadron-level maintenance supervision/staff. The analysis was repeated for each group individually, allowing for observation of how the two levels of job function may differ in their views of the criticality of the perspectives or measures.

Three BSC software packages, ActiveStrategy Enterprise™, SPImpact, and pbviews, were reviewed to evaluate their adherence to relevant industry standards. Relevant features range from network compatibility to user ease and friendliness. It was observed that pbviews contains all the preferred features.

2 Introduction

2.1 Project Description

The AFRL/HEAL identified a need to have a strategically aligned performance measurement system for flightline MX activities. This performance measurement system must account for the entire flightline MX process in order to improve the performance of aircraft scheduling and achievement of mission objectives. It is known that successful achievement of mission objectives is the result of a coordinated effort between multiple organizations and a variety of processes. These coordinated efforts require proficient levels of preventive maintenance, degree of training and experience, quality and timeliness of suppliers, and many other factors. Focusing on a single component of the flightline MX process to the exclusion of other components can cause short-term benefits but long-term performance degradation and failed objectives.

The primary project activities are:

- ◆ Identification of a strategically aligned performance measurement system
- ◆ Research into that system's development and implementation process
- ◆ Investigation of current flightline MX processes
- ◆ Production of associated development guidelines
- ◆ Validation of these guidelines through a case application
- ◆ Investigation of software implementations

The review of the performance measurement literature resulted in the selection of the Kaplan and Norton BSC as the appropriate measurement system for the flightline MX process. Further review of the BSC literature included a sampling of the major works in this area. This review included the history of the BSC and focused on the various components of the traditional corporate BSC and the possible adaptations to a defense organization.

Production of the BSC development guidelines required in-depth analysis of the traditional BSC development process and the current flightline MX processes through documentation review and site visits. The guidelines prescribe the process from selection of both a target organization and development team to the classification of measures and families to the production of a viable BSC. The methodology contains a review and revision process to ensure that the resulting BSC stays current.

To the extent possible, the BSC development guidelines were used to develop a candidate flightline MX BSC. This was done to validate the development guidelines to ensure practical implementation. The resulting BSC was validated through administration of a questionnaire to USAF logistics personnel. While strongly based upon feedback from USAF personnel, this BSC was predominately externally developed. To be truly strategically aligned, a BSC must be developed by the target organization. The BSC is a system that involves a great deal of direct knowledge about the system being monitored. There is extremely valuable process information to be gained throughout the BSC development process.

It was determined that a review of existing BSC software packages would benefit eventual implementation of the BSC. A review of the three most prominent BSC software packages was conducted based upon the existing standards for such packages.

Three BSC software packages, ActiveStrategy Enterprise™, SPImpact, and pbviews, were reviewed to evaluate their adherence to relevant industry standards. Relevant features range from network compatibility to user ease and friendliness. It was observed that pbviews contains all of the preferred features.

2.2 Objectives

The project's overall goal is to formulate BSC development guidelines that will facilitate strategically aligned performance measurement through the identification of mission-critical performance measures that seek to improve the performance of aircraft scheduling and achievement of mission objectives.

The project objectives are to:

- ◆ Identify a strategically aligned performance measurement system, i.e. the BSC, through an in-depth review of the relevant literature
- ◆ Investigate and develop realistic development guidelines through review of BSC literature, related USAF documentation and site visits
- ◆ Validate the BSC development guidelines through a case application and practitioner assessment of the resulting BSC
- ◆ Investigate BSC software packages to help facilitate successful implementation

3 Background

3.1 Flightline Maintenance Process

The project scope is the flightline MX process. The flightline MX process is the inspection and service process that takes place from the time an aircraft lands through all the activities necessary to recover the aircraft and prepare it to successfully complete another mission. The cyclical process is depicted in *Figure 3.1* (Flightline Orientation Briefing, 2003). While each stage of the process is described briefly in this section, the complete related documentation from the orientation briefing is located in *Appendix 1*. Thorough knowledge of this process is required to determine the relevant performance measures, understand why the measures behave as they do, and indicate reasons why these measures fall outside acceptable parameters.

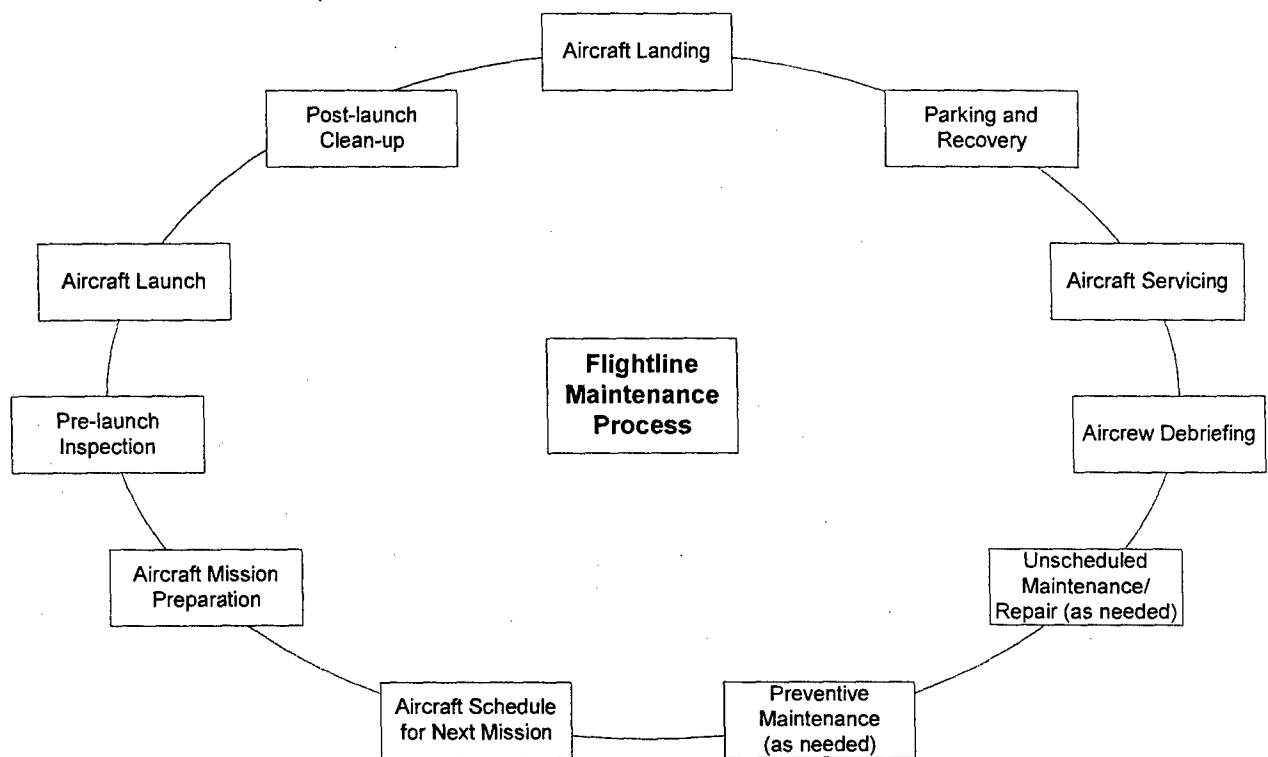


Figure 3.1: Flightline Maintenance Process

3.1.1 Aircraft Landing

The MX process begins when an aircraft returns from a mission. As the aircraft lands, the aircrew relays system discrepancies to the flightline. This allows the flightline to be prepared for the discrepancies and make repairs faster.

3.1.2 Parking and Recovery

The parking-and-recovery stage neutralizes the threat of munitions and fuel explosions through grounding and stabilizes landing gear. The processes in this stage should be strictly monitored for safety standards adherence. Performance measures used for this process should reflect an emphasis on safety.

3.1.3 Aircraft Servicing

Aircraft servicing actions include checking system fluids and refueling. This is another stage where safety is paramount. Essential measures include training measures to ensure that training is up-to-date and the most recent practices are adhered to.

3.1.4 Aircrew Debriefing

Aircrew maintenance debriefing is the communication between the aircrew and the MX crew. The debriefing has a large impact on the quality of repairs completed by the MX crew. A complete debriefing is an important factor for quality performance measures such as repeat recurrences. This process is aided by the use of different codes for landing status, system capability, and deviations.

3.1.5 Unscheduled Maintenance/Repair

The success of the unscheduled MX and scheduled MX operations indicate the health of the supply chain through the length of time to receive parts and the number of backorders on those parts.

3.1.6 Preventive Maintenance

Preventive MX operations can be good indicators of the ability of a MX unit to manage its schedule efficiently. Operations such as Time Compliance Technical Orders (TCTO), Time Change Item (TCI) replacements, and system calibrations further reduce wear on aircraft and increase a MX unit's ability to keep planes in the air.

3.1.7 Aircraft Scheduled for Next Mission

Aircraft scheduling for the next mission and aircraft mission preparation are essential for successful mission completion. In this stage, aircraft are scheduled and prepared for various missions. Success in these stages has a direct impact on the number of maintenance-chargeable deviations incurred.

3.1.8 Pre-launch Inspection

Pre launch inspection involves detailed MX and aircrew inspections including visual examination of the aircraft and operationally checking certain systems and components.

3.1.9 Aircraft Launch

The aircraft launch requires the aircrew to start the engines, power up systems, and make final adjustments in preparation for launch.

3.1.10 Post-launch Check-up

The last step in the process involves cleaning up the parking location.

3.2 Maintenance Performance Measurement

Maintenance leaders are primarily concerned with knowing how well the unit is meeting mission requirements, improving equipment performance, identifying support problems, and projecting current trends (AFLMA, 2001). It is pertinent that MX leaders review sortie production and MX performance constantly and are knowledgeable about predictive MX indicators. Maintenance performance is generally assessed using standards, goals and maintenance plans. The following performance measurement questions were developed by the AFLMA (2001):

- ◆ Are operational requirements based upon realistic availability of equipment?
- ◆ What are the causes of flying schedule deviations?
- ◆ Are particular aircraft, equipment, systems, or subsystems contributing to a disproportionate share of deviations?
- ◆ Does specific equipment fail to perform as scheduled or require more or less MX than normal?
- ◆ Is there enough staff to meet mission needs?
- ◆ Do higher rates of repeat/recur discrepancies indicate training or experience shortfalls?
- ◆ Is there sufficient time to schedule and work MX problems?
- ◆ What is the behavior of MX trends?

There are two prominent types of performance indicators associated with maintenance: leading and lagging. Leading indicators directly impact MX capability to provide resources to execute the mission by measuring performance before a problem arises. Lagging indicators provide information after the problem has occurred and can indicate firmly established trends.

3.2.1 Leading Indicators

Maintenance Scheduling Effectiveness (MSE) Rate - The number of maintenance actions started as scheduled per total number of MX actions scheduled. MSE rate measures maintenance's ability to plan and complete inspections and scheduled MX.

DD Rate – DD rate depicts how well the unit is keeping up with required minor repairs. Deferred discrepancies are minor MX actions that may be deferred until a more opportune time.

3.2.2 Lagging Indicators

Fully Mission-Capable (FMC) Rate - A low FMC rate may indicate a parts problem. This measure should be compared with the monthly MC rate. Significant differences may indicate that aircraft are flying partially inoperable.

TNMCS Rate - This rate is based upon the number of airframes out for parts; therefore, spare part availability is critical for this measure. Maintenance can reduce this rate by limiting the number of CANNs.

3.3 Balanced Scorecard

Kaplan and Norton (1996) introduced the Balanced Scorecard (BSC) in the early 1990s. The BSC was introduced in an attempt to reconcile problems in traditional management strategies. Traditional management strategies overemphasized financial measures at the expense of progress and growth. This overemphasis brought about short-term gains to the detriment of long-term success. The BSC is a performance management system that allows organizations to clarify their strategy and assure that every aspect of operations is directed toward the success of these goals (Balanced Scorecard Basics, 2003). When considering important measures all at once, as suggested by the BSC, management can detect whether one area is improving at the expense of another area (Kaplan and Norton, 1996). Kaplan and Norton suggest the following analogy to better explain the purpose of the BSC. In a cockpit, a large and complex amount of data is displayed very quickly and simply through the use of cockpit displays. These display fuel level, airspeed, altitude, bearing, and destination. Focusing on just one instrument can be

fatal, just as focusing on one aspect of performance can be fatal to operational success. A BSC is designed to display all pertinent performance information simultaneously.

Kaplan and Norton state that, in addition to the traditional financial performance measures, the BSC incorporates non-financial measures that enable value creation for the organization (Kaplan and Norton, 1996). These measures have focused on managing intangible assets such as customer relationships, skills and knowledge of the workforce, and the technology that supports the workers (Kaplan and Norton, 2001). A graphical representation of the BSC is depicted in *Figure 3.2* (Kaplan and Norton, 1996).

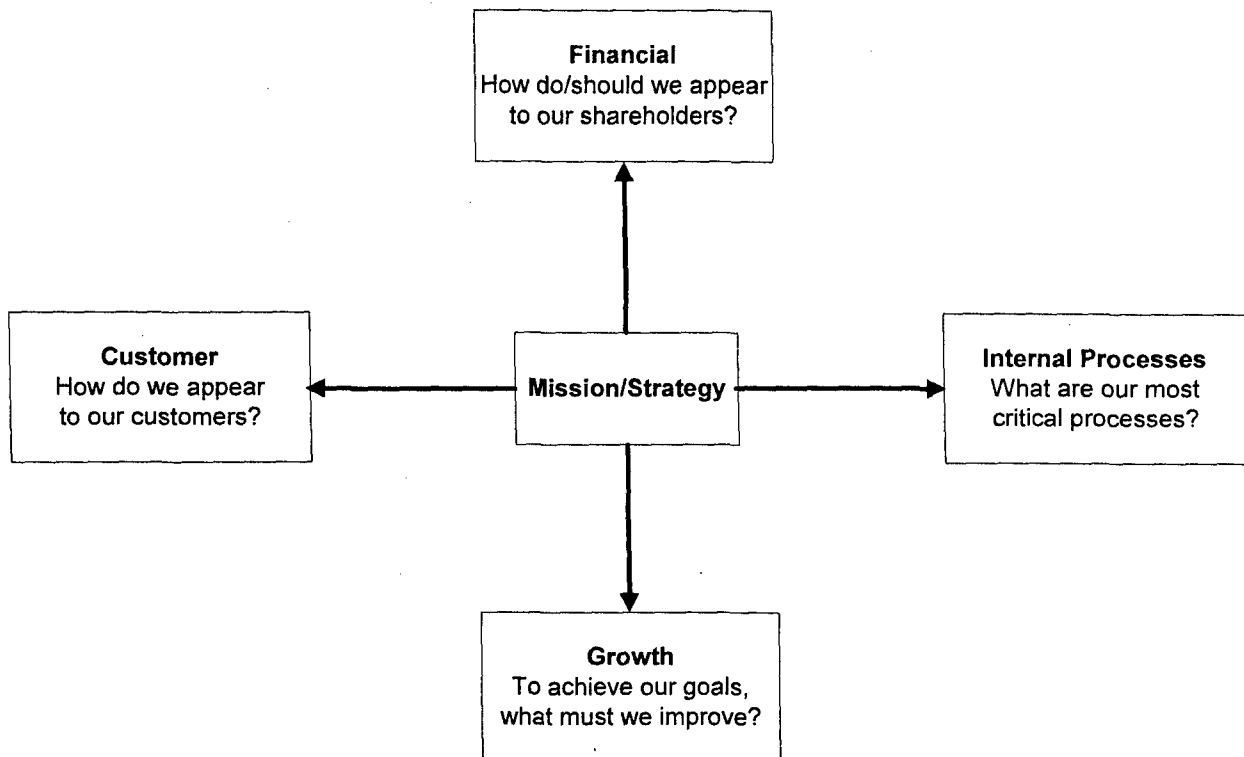


Figure 3.2: BSC Framework

The original four perspectives of the balanced scorecard (financial, customer, internal processes, and learning and growth) are focused on the mission or strategic plan of an organization. In order for an organization to achieve its goals, it is important that any performance measurement system be aligned with and contributing to the overall mission of the organization.

3.3.1 Financial Perspective

The financial perspective is the objective perspective and represents factors that contribute to successful company cash flow and market share. Although financial measures may provide management with numeric data concerning the company's performance, these are lagging indicators of past events. Crandall (2002) states that traditional performance measurement systems rely too heavily upon financial measures and neglect issues such as quality and customer service. Tracking the performance of past events through financial performance measures is important; however, non-financial measures that help create value should also be considered.

3.3.2 Customer Perspective

The customer perspective is more closely related to the company's mission statement than the widely implemented financial measures. A large number of companies today have a mission statement that focuses on customers (Kaplan and Norton, 1996). This perspective incorporates customer issues into the company's performance measurement system. Taking customer concerns into account is a critical aspect of operating a business and should therefore be included in the company's performance measurement system.

3.3.3 Internal Business Perspective

The internal business perspective is concerned with measures such as timeliness of operations, actual vs. planned activities, and issues with competition. This perspective is intended to measure what the company is doing internally to address the needs and wants of the customer. The internal measures associated with the BSC are derived from internal processes that have a significant impact on customer satisfaction. Kaplan and Norton (2001) state that this perspective captures an organization's activities. Achievement of operational excellence through the improvement of internal processes and supply chain management are activities that should be captured with this perspective (Kaplan and Norton, 2001).

3.3.4 Learning and Growth Perspective

The learning and growth perspective is the foundation for corporate strategy. This is the perspective where management assesses their employee ability, technological status, and corporate climate needed to support a strategy (Kaplan and Norton, 2001). This perspective includes training employees and shaping attitudes to promote self-improvement (Balanced Scorecard Basics, 2003). It is important that the organization has long-term goals and a strategy in place with targets to be achieved to promote growth.

4 BSC Development Guide

The BSC development process is one that requires thorough knowledge about internal operating procedures and a comprehensive understanding of the system being studied. It was determined that detailed guidelines for the BSC methodology would be valuable to facilitate the development of BSCs for flightline MX personnel. These guidelines are designed for use by USAF personnel with little or no BSC experience to develop scorecards for the flightline MX process. Adherence to the development guidelines is pertinent for developing a strategically aligned BSC. The guidelines assure that every step is followed by dividing the BSC development process into manageable stages. *Figure 4.1* depicts the BSC development process, which consists of the three primary stages: Groundwork, Design and Finalization. Each stage is comprised of multiple steps, which are detailed in the remainder of this section.

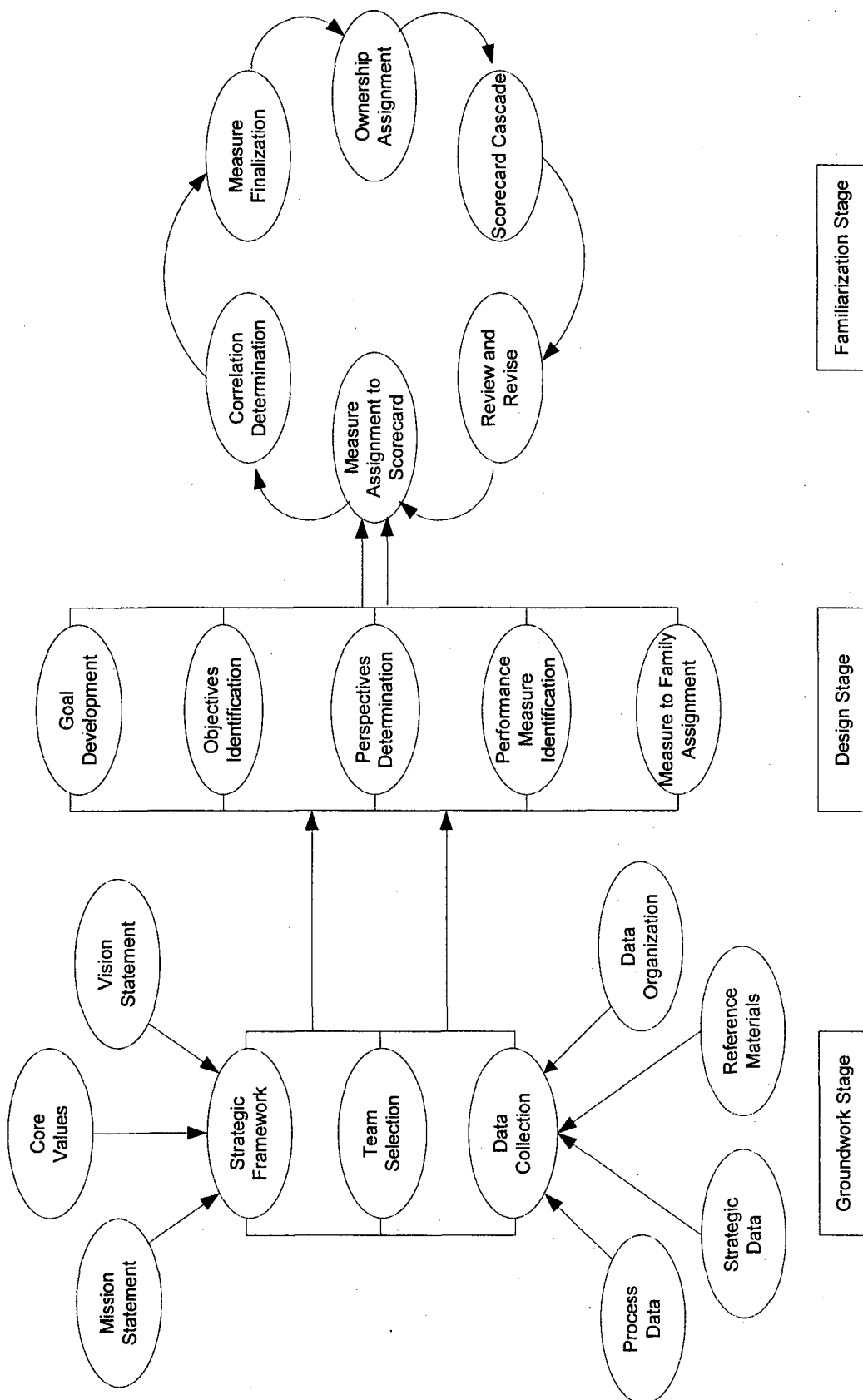


Figure 4.1: BSC Process Diagram

4.1 Groundwork Stage

The groundwork stage is the foundation of a successful BSC project. By following the steps in this stage, all the pertinent and necessary information needed for the scorecard will be available during construction. A thorough groundwork stage will assure that key information is not overlooked. It will also assure that the gathered information is organized in a logical manner.

4.1.1 Team Selection

The BSC should be undertaken by a team of stakeholders, not a single person. This allows for brainstorming and group discussion. It also facilitates thorough review of report documents. The team should be comprised of personnel from all involved functions and should represent the skill sets in the organization. Inclusion of all stakeholders will facilitate acceptance and enthusiasm for BSC implementation. The members of the BSC team will act as ambassadors for the BSC, accelerating its acceptance and use (Niven, 2002). Each team member should be qualified to provide expert opinion about his or her organizational function. An understanding of BSC concepts and its development process is imperative for all team members. Skill in quantitative analysis must also be present among the team as this is extremely useful during the finalization of measures.

While team size is ultimately up to the team leader, a standard BSC team has approximately seven members. In general, more than seven members may create difficulties in coordinating group efforts; less than seven may not bring enough viewpoints to the process. The team leader is responsible for coordinating all team meetings and corresponding with superiors (Niven, 2002). Other members of the team may be assigned specific duties as needed during the development process.

The goal for team member selection is to represent as many levels of the organization as possible. The reasoning behind this goal is that a higher-level supervisor, such as a unit commander, understands overall strategy and desired outcomes of the organization. In addition, there are many low-level aspects of operations that are important to performance measurement. These are better understood by the persons who work at this level every day.

4.1.2 Strategic Framework

Organizational strategy is the guiding factor behind the BSC. Organizational strategy is defined as a set of long-term goals that, if successfully achieved, will revolutionize the way a unit operates. Without strategic alignment or the integration of this organizational strategy into the BSC, a BSC is merely a

collection of performance measures. Strategic planning and alignment to a given strategy should be the top priority in any BSC venture. There is a large gap between having a good strategy and effectively implementing it. The BSC provides a framework to transition from deciding to have a strategy and actually using it (Niven, 2002). The next section discusses gathering a few basic strategic components. Identification of an organization's strategy will help determine the most relevant data to collect.

The process of strategic alignment begins at the top of the participating organization, regardless of its scope or size. The unit commander and relevant subordinates must come together to determine what the organizational strategy is and where opportunities for achievement of this strategy exist. This is a complex process requiring time and effort. There is often disparity between the commander and other members of the organization on how the organizational strategy is to be implemented. In many cases, a documented strategy does not exist. In this case, a sound organizational strategy must be developed. The essential strategic elements for a successful BSC are mission, core values, and a vision statement (Niven, 2002). If these strategic elements are already in existence and are approved by the team, they can be integrated into the framework. Otherwise, these elements must be developed as described in *Sections 4.1.2.1 through 4.1.2.3*.

4.1.2.1 Mission Statement

Mission statements have been adopted by almost every organization in existence. They are used to communicate fundamental beliefs and identify target goals (Kaplan and Norton, 1996). A mission statement should be motivating and inspiring. An effective mission statement is not something that changes every year but lasts for many years as a foundation for the organization. A mission statement should be easily understood and communicated down to the lowest level of the organization (Niven, 2002). An example mission statement is that of the USAF: "To defend the United States through control and exploitation of air and space."

4.1.2.2 Core Values

Niven holds that "values are the timeless principles that guide an organization" (Niven, 2002). These principles are deeply held beliefs that exist within the organization and are demonstrated through the day-to-day behaviors of all employees. These values set the tone for an organization by telling each member of the unit how to accomplish his or her mission. For example, the core values of the USAF are:

- ◆ **Integrity** – Do the job right the first time
- ◆ **Service** – Mission accomplishment over personal gain
- ◆ **Excellence** – Put forth the best possible effort all the time

4.1.2.3 Vision Statement

A vision statement is a snapshot of the future. An excellent example of a vision statement is the USAF's "*Global Vigilance, Reach, and Power: Vision 2020*" (Vision 2020, 2000). It contains multiple long-term goals that can take anywhere from several years to a few decades to achieve. Many of the long-term goals from a vision statement can help to define the characteristics of the BSC perspectives. It is important to avoid vague catchwords and phrases. The use of very technical words is also discouraged since all stakeholders may not be familiar with such language. It should be clear to all stakeholders, not just the upper command, where the organization is going and exactly how they plan to get there (Brown, 1996).

4.1.3 Data Collection

Data collection is an essential step in the BSC development process. The following subsections describe the key types of data and data collection activities. The development of a BSC generates large amounts of data. This data must be organized and stored in a logical manner to prevent contamination or loss of pertinent information. One team member should be delegated the responsibility of organizing the data and keeping it up-to-date by maintaining the latest version of all relevant documentation. Master copies of all reference materials should be accessible in a secure, central location. This protects the data and provides ready access to team members.

4.1.3.1 Process Data

The first step in data collection is to collect data on the processes that are to be monitored by the BSC. Details on process data collection are as follows:

- ◆ Determine exactly what each process is and locate any existing documentation about the process
- ◆ Determine the chain of command for the process
- ◆ Document the current process as it occurs in the organization
- ◆ Compare and contrast the existing and team-developed documentation about the current process.

4.1.3.2 Strategic Data

The next step is collecting strategic planning data from the highest-level command. This data collection does not exclusively involve the highest-level commander, but all those involved in strategic planning or leadership of the unit. This information is essential for the strategic planning portion of BSC development. Specifically, it will help determine what measures should be monitored and how they should be linked throughout the scorecard. This data should be gathered in personal interviews with the

commander and others involved in the strategic planning process. The following are pertinent questions to have answered (Niven, 2002):

- ◆ What is your interpretation of the Mission Statement, Core Values, and Vision Statement?
- ◆ Who are your customers?
- ◆ What key strategies will help to achieve your vision?
- ◆ How can these strategies be achieved?
- ◆ What measures or data do you track to monitor success?
- ◆ What targets do you use for these measures?
- ◆ What related reports do you find most useful?

4.1.3.3 Reference Materials

Reference materials are published documents that contain information on processes and their performance measurement. Reference materials also include information pertaining to the BSC and its application. These materials assist in identifying measures and perspectives for the scorecard and indicate the relative importance of measures or processes. It is essential to gather materials from as many different sources as possible. Following is a sample of potential sources:

- ◆ **Published manuals and training guides** – These documents provide information on what performance-related information the unit already monitors. Manuals are an excellent information source for potential BSC measures and instruction on how they should be monitored.
- ◆ **Health of Fleet (HOF) Reports** – HOF reports are a source for many measures that are already tracked and reported. Since these measures are already in operation, it is much easier to integrate these measures into a BSC.
- ◆ **9302 Reports** – Since performance measurement of the measures on the 9302 reports are required by Air Combat Command (ACC), these measures are considered vitally important.
- ◆ **Public Literature** – Published research provides information on the BSC and its development and implementation.
- ◆ **Performance Documents** – Any documents other than those named above that contain relevant performance measures should be used.
- ◆ **Expert interviews** – Personnel with a high level of experience in their unit or career track can often suggest additional important measures other than those currently being monitored.

4.2 Design Stage

The design stage begins with structuring the strategic elements of the organization and progresses through performance measure identification and construction of the basic BSC framework.

4.2.1 Goal Development

Strategic planning informs everyone in an organization where he or she is going and how to get there. Effective development of a strategy was outlined in *Section 4.1.2*. The conversion of this strategy into goals is the topic of this section. The overall strategy must be broken down into long-term goals. These are goals that can revolutionize the way an organization operates by taking them from their current state to envisioned future success. These goals should be future-focused with a time frame ranging between five to 20 years. Milestones should be identified to divide the long-term goals into shorter time buckets. Milestones are subdivisions of a goal that are used to check progress toward achievement of the goal. These long-term goals can then be transformed into performance measures later in the BSC development process. Each goal must have a specific target that is either numerical or descriptive. These targets are the projected optimal result for each goal.

Brown (1996) identifies five common problems associated with setting goals, as listed below. All pertinent goals should be reviewed to verify that they do not contain any of these flaws.

- ◆ Goals that are really projects, activities, or strategies – The best way to avoid this is to ensure that each goal has at least one measure in the scorecard.
- ◆ Goals that are solely based upon past performance – Many organizations simply add five or ten percent to last year's goal without justification.
- ◆ Arbitrary stretch goals – Developing a goal without good reason or randomly selecting a competitor's goal should be avoided.
- ◆ Inconsistent short-term and long-term goals – All short-term goals should be components of some long-term goal.
- ◆ Inconsistencies in goals at different levels of the organization – Every goal should cascade down from a higher goal.

4.2.2 Objectives Identification

Identifying objectives is a translation of strategy and long-term goals into specific timelines and events. Each long-term goal has a realistic target, and milestones have been identified as a portion of that target.

These goals and targets will be placed as measures in the objective perspective to show success in strategic objectives.

4.2.3 Perspectives Determination

As previously discussed in *Section 3.3*, the original Kaplan and Norton (1996) BSC suggested four perspectives:

- ◆ Financial Perspective
- ◆ Customer Perspective
- ◆ Internal Business Process Perspective
- ◆ Learning and Growth Perspective

Kaplan and Norton recognize these four perspectives “should be considered a template, not a straight jacket.” Their perspectives are intended to portray the essential elements that can lead to success in a typical organization (Kaplan and Norton, 1996). Although four is standard, there is no set rule for determining the number of perspectives in a scorecard. While fewer than four is uncommon, there are many instances of more than four. If there are more than four key elements that give a competitive edge or portray key competencies, these should all be included as perspectives; however, care should be taken when adding perspectives, because too many perspectives can lead to scorecards with large numbers of stand-alone perspectives that are unrelated to each other. Niven (2002) suggests that the true test of perspectives is whether they can be intertwined to tell a coherent story. As shown in *Figure 4.2* below, success in any one perspective can be linked to success in the others. Improvements in lower perspectives lead to good results in higher perspectives, which then lead to realization of the vision (Niven, 2002). This linkage is further discussed in *Section 4.3.2*.

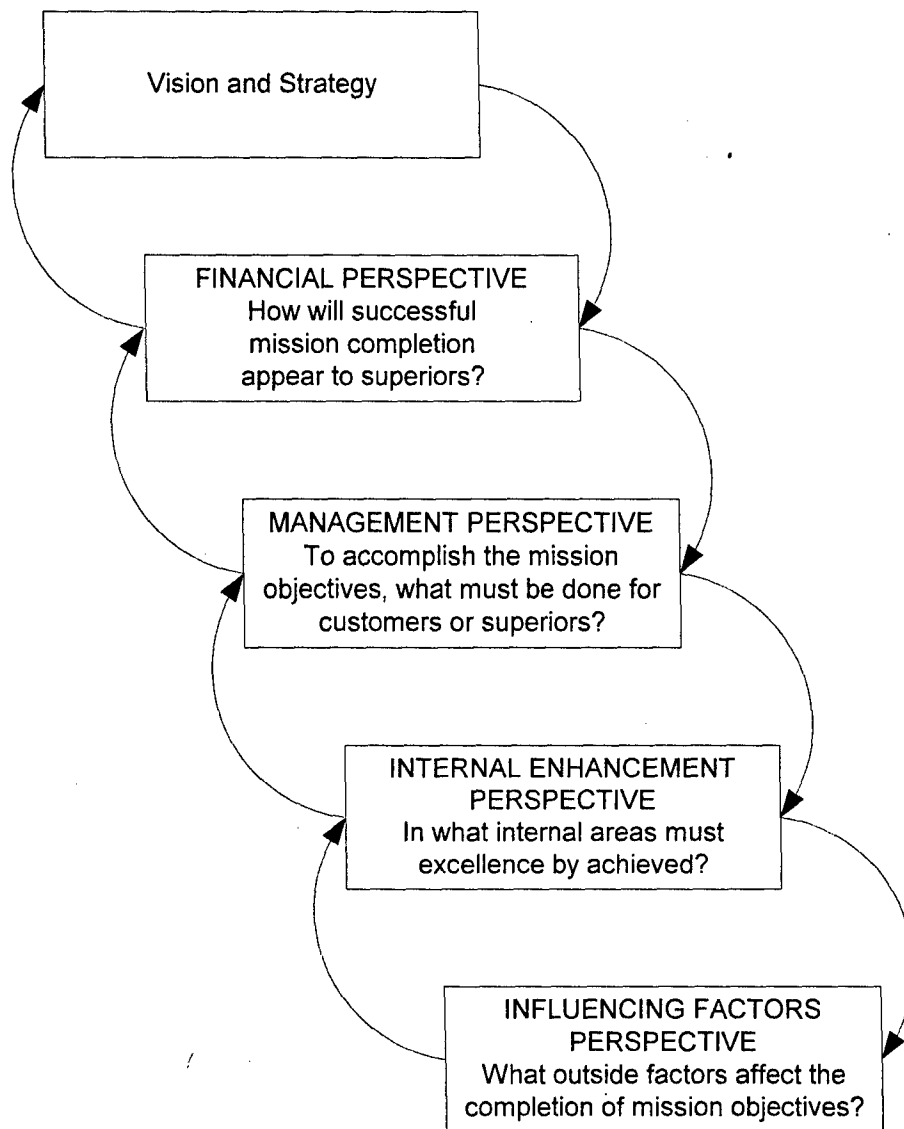


Figure 4.2: Perspective Linkage

(Adapted from Kaplan and Norton, 1996)

4.2.4 Performance Measure Identification

At this point in the development process, there is a success strategy mapped out, and objectives for success have been determined. Using these objectives, the BSC perspectives have been identified. The next step is to determine possible measures for inclusion in the BSC. Using the materials gathered during the groundwork stage, all relevant performance measures should be identified and listed. Each document should be thoroughly reviewed and all identified measures should be compiled. Equations or formulae used to calculate the measures should be included along with any targets for each measure. This list

serves as a pool from which to draw the key measures for the performance objectives. This list is not yet the master list of measures; this is the list of measures that are currently being tracked. During the development of the performance objectives, it may become apparent that additional measures that are not currently tracked are needed to track the BSC objectives. These new measures will become more apparent as the project progresses and should be listed separately as they are identified. Along with all measures listed, it is useful to have a set of parameters such as: maximum, minimum, optimal, and benchmark (how other similar organizations perform). Data without goals or comparisons are meaningless (Brown, 1996). For example, knowing that the phase average for a B-52 wing is 215 hours is not useful information unless it is known that the phase average should be approximately 150 hours. The comparison data is what indicates the actual performance of a measure.

4.2.5 Measure to Family Assignment

After the list of measures is compiled, a logical organization needs to take place. The measures are assigned to families based upon similar characteristics and/or applications. An example of a measure and its family is "sorties flown" and the "Productivity Family." "Sorties flown" measures productivity when used in the context of a maintenance unit; therefore, it is assigned to the family of productivity-related measures. Assigning measures to families is an initial starting point to the construction of the BSC. Once families are created, they are assigned to perspectives in the BSC. It is important to note that each family should be included in only one perspective; however, one perspective can be comprised of more than one family. This facilitates a smooth process for adding measures to the scorecard. If a productivity measure is required, it can be drawn from the Productivity Family. If a measure becomes too expensive or cumbersome to measure, it can be replaced by another similar measure from the same family.

4.3 Finalization Stage

The finalization stage is the continuous improvement stage of the development process. This cyclical stage includes assignment and reassignment of measures to the BSC based upon their pertinence to the ever-changing activities and current strategies of the organization. This stage continues over the life cycle of the BSC.

4.3.1 Measure Assignment to the BSC

An exhaustive list of currently tracked performance measures and candidate new measures now exist. The next step is to select measures from this list for inclusion in the BSC. In the measure selection process, it is important to note that a single person or scorecard should monitor no more than 20 measures (Brown, 1996). If necessary, measures can be combined into aggregate measures. Aggregation of measures is

discussed in *Section 4.3.5*. When selecting measures, the most important factor is to ensure that each chosen measure reflects the strategies developed earlier in the process.

Caplice and Sheffi (1994) provide eight evaluation criteria that can be used to pare down the exhaustive list of measures into the measures that will eventually be included in the BSC. These eight criteria are listed and defined in *Table 4.1*. Trade-offs exist between these criteria and will need to be evaluated based upon organizational priorities.

Table 4.1: Eight Criteria Measures

Criterion	Description
Validity	The measure accurately captures the events and activities being measured and controls for any exogenous factors
Robustness	The measure is interpreted similarly by the users, is comparable across time, location, and organizations, and is repeatable.
Usefulness	The measure is readily understandable by the decision maker and provides a guide for action to be taken.
Integration	The measure includes all relevant aspects of the process and promotes coordination across functions and divisions.
Economy	The benefits of using the measure outweigh the costs of collection, analysis, and reporting.
Compatibility	The measure is compatible with the existing information, material, cash flows and systems in the organization.
Level of Detail	The measure provides a sufficient degree of granularity or aggregation for the user.
Behavioral Soundness	The measure minimizes incentives for counter-productive acts or game playing and is presented in useful form.

Specific examples of criteria trade-offs are discussed next. A measure that is behaviorally sound may be very uneconomic. That is, the measure may prevent cheating the system very well, but the cost of the required supervision is prohibitively expensive. Another possible trade-off exists between the criteria usefulness and level of detail. A measure that is readily understandable may be so watered down that it is a poor reflection of what is actually going on and therefore useless. One method for making priority trade-offs between these criteria is the use of a weighting system. Each criterion is assigned a priority weight with the sum of all the weights normalized to 100 percent. Each measure is then assigned a weight

corresponding to its value/importance to each criterion. The weighted sum of each measure is calculated and the measures with the highest ratings are selected. This provides an efficient, quantitative method for deciding between similar measures; however, this should not be the only selection criterion. Team expertise and opinion on strategic prioritization should be employed when deciding between measures.

4.3.2 Correlation Determination

This can be the most challenging step in the development of an effective BSC. A scorecard without strategic linkages is simply a group of unrelated performance measures. The key is to determine how the strategy relates to each perspective in the BSC. Determining correlations, for example, the way in which each perspective contributes to the success of the overall strategy, begins with the objective perspective. This perspective contains the strategic goals for an organization, and all improvements elsewhere in the BSC should positively affect it. The correlation process works through each perspective, showing how each perspective relates to the objective perspective. Next is an example to exemplify this process.

The correlation process deals with building linkages from the other perspectives into the objective perspective. The objective perspective contains measures that directly reflect the accomplishment of objectives identified in *Section 4.2.2*. With the introduction of measures into each perspective of the BSC, the following analysis should take place. First, the questions listed in *Section 4.3.1* should be asked about each measure included in the perspective. Subsequently, relationships between success in this measure and success in other measures already in the BSC should be sought. This relationship can be between the new measure and a measure in the objective perspective, or it can be between the new measure and a measure elsewhere in the BSC that has already been linked to the objective perspective. If no linkages can be identified, the measure is either a diagnostic measure or has no reason to be on the scorecard. For more information on distinguishing between diagnostic and strategic measures, see *Section 4.3.3*.

After determining how the strategy is reflected in the measures, a hypothesis should be made about their correlation. The hypothesis is a prediction of how improvements in each perspective will lead to an improved bottom line in the objective perspective. As a hypothetical example, an increase in "departure reliability" in the "Management Perspective" of ten percent may have a positive impact on "sorties flown" in the objective perspective of three sorties more per month. Each hypothesis should be tested and revised to give a more accurate correlation as needed. During the infancy of the scorecard, the testing and revision should occur frequently, possibly every quarter. As the BSC matures, testing and revision may occur once a year or less. Occasionally, the hypothesis turns out to be false and the hypothesized

correlation does not exist. Upon determining that a hypothesis is false, it should be eliminated and replaced with a new strategically aligned hypothesis.

As a hypothetical example, a strategic correlation related to the goal of increasing air superiority is discussed next and shown in *Figure 4.3*.

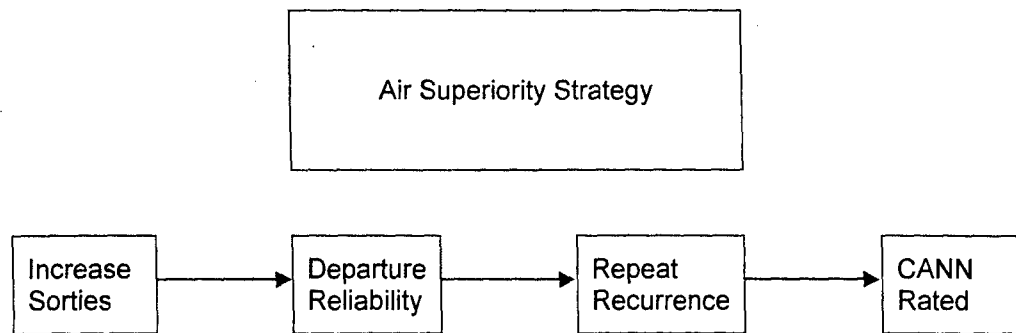


Figure 4.3: Hypothetical Strategic Correlation

Suppose the strategy for air superiority is an increase in sortie generation of ten percent over the next five years. "Sorties flown" is chosen as the measure to describe this goal. "Sorties flown" is located in the objective perspective and is directly affected by "departure reliability" in the "Management Perspective." It is hypothesized that an increase in "departure reliability" will directly affect sortie generation. In order to increase "departure reliability," "repeat recurrences" must be reduced. As the cannibalization of parts reduces mission capable planes and increases wear and tear on parts, it could have an adverse effect on "repeat recurrences"; therefore, a reduction of the "CANN rate" will help achieve fewer "repeat recurrences." It must be recognized that this is a completely hypothetical example, created to illustrate the process of forming strategic correlations. It is important to note that each of the amounts hypothesized should be based upon the principles of effective goal forming given in *Section 4.2.1*.

4.3.3 Measure Finalization

The pared-down measures can now be assigned to the actual scorecard. These measures were selected based upon their strategic linkage in the scorecard and accurately depict the strategy of the organization. At the conclusion of an initial BSC development, there may be gaps in the correlation where the correlation does not continue all the way through the scorecard. The gaps in the correlation indicate where strategic planning needs to include other aspects, such as internal enhancement or influencing factors. The BSC bridges the strategic gap between organizational success and the factors that influence it. After any

gaps in the correlation are filled, there may be other measures that still need to be added. These are called diagnostic measures, which are not linked to strategy but are still important. These measures describe key operating statuses. The scorecard can be analogically compared to a car dashboard. The speedometer, odometer, and tachometer are strategic measures. The diagnostic measures are the low-gas light, engine-maintenance light, and the low-oil pressure light. Diagnostic measures help to identify problems before they become serious.

4.3.4 Ownership Assignment

This is an essential step in BSC development. Each measure must have an owner who is responsible for tracking the measure. The owner has the responsibility to provide thorough documentation describing the measure, provide reasoning for past performance, and supply other information that will help others to interpret and assess the measure. Although a measure may appear on multiple scorecards, there is never more than one owner. The use of multiple scorecards is discussed in the following section.

4.3.5 Scorecard Cascade

In general, the first BSC developed in any organization is a high-level BSC. After a high-level BSC has been created, it should be cascaded. Cascading is a form of subdivision of measures. The measures on a high-level scorecard are often comprised of other lower-level measures or aggregates. Cascading is the structuring of these lower-level measures into lower-level scorecards. As previously noted, each person should only have twenty or fewer measures to monitor. The common practice in cascading a scorecard is to have each manager create a scorecard tailored to his or her responsibilities. Their scorecards contain measures that aggregate into the measures on the higher-level scorecard. An example of aggregate measures would be wing "sorties flown," which is comprised of the "sorties flown" in each squadron. A hypothetical example of a cascaded scorecard would be each squadron's measure of "sorties flown" feeds into the aggregate measure of "sorties flown" on the wing scorecard. The lower-level scorecards will focus on unit-specific responsibilities. The measures on a high-level scorecard are generally very abstract while the measures on the lower-level scorecards become increasingly more concrete. When cascading scorecards, it is important to put only the measures necessary to the person or unit who uses the scorecard. A scorecard for the flightline will not contain measures that pertain to munitions; however, the higher-level scorecard over both these units will contain measures from both flightline and munitions.

4.3.6 Review and Revise

Periodically, a BSC must be revised and updated. This review and revision should take place frequently during the infancy of the BSC. In the beginning, reviews should take place every quarter and continue

until the hypotheses made in *Section 4.3.2* have been validated. As the BSC matures, reviews can be conducted annually or as strategic planning requires. Basic revisions can take place at any time. These can include cascading down additional scorecards when new units are added or reorganized. Strategic reviews should occur on the completion dates of milestones or after any change in organizational strategy. At this time, major changes can be made to the scorecard, such as strategy changes, using different measures, or changing targets for measures.

5 BSC Field Study

Section 4: BSC Development Guide provides comprehensive guidelines for developing a BSC. In this section, a case study is presented that describes the process undertaken by our team to validate and exemplify the *BSC Development Guide*. The team developed a preliminary BSC for flightline MX activities within an AMU. For each step of the BSC Development Guide, this section provides an explanation of the work performed by the team and description of how the USAF contributed.

5.1 Groundwork Stage

5.1.1 Team Selection

As was noted in *Section 4.1.1*, a team must be assembled to develop a BSC. The BSC team is typically made up of multiple members of a unit who are intricately involved in the development process. Since this is an external project, the team was created in a unique manner. The team was organized according to the expertise of University of Arkansas faculty and student research assistants. Because of the external nature of the project, USAF personnel from the AFRL, Hill Air Force Base (AFB), and Barksdale AFB collaborated with the team throughout the project.

5.1.2 Strategic Framework

Formulating a strategy is essential to providing the overall goals and objectives that are linked to the BSC. The team investigated the important goals of the AMU through site visits, personal interviews, and review of USAF documentation. The collected information shaped a strategy for the BSC. The developed strategy is only intended to validate the correlation process for the preliminary scorecard. Using the knowledge gained throughout the data collection process, the team formed and utilized the following statement as the overall strategy for our preliminary BSC: "The strategy of a typical AMU is to work toward improvement of combat capability by meeting key maintenance performance indicators."

5.1.3 Data Collection

Data collection is at the heart of a successful BSC. Without pertinent and accurate data about the process being studied, the exhaustive list of possible measures cannot be correctly formulated. In producing the preliminary BSC, the team gathered multiple sources of information. The team started by analyzing the initial problem statement and developing questions about the scope of the project. The team needed complete knowledge of how a BSC was formulated and implemented. An extensive literature search was conducted on documentation about the BSC approach and applications of this approach within industry.

This literature was important because it helped further explain the necessary methodology for building a BSC and organize the team's thoughts on how to apply the BSC specifically to the USAF. Also, in order to best develop the *BSC Development Guide*, the team needed a vast amount of information about the AMU. The information provided by the USAF included specific sources for measures and their targets and a general overview of the command hierarchy within the USAF MX organization. This information was provided through multiple sources discussed in the following sections.

As discussed in *Section 4.1.3*, organizing collected data is vital to the development process. To maintain the integrity and security of the collected information, all documents were kept in a secure location with immediate access by team members.

5.1.3.1 Process Data

As stated in *Section 4.1.3.1*, process data is used to describe what actually occurs during the process for which the BSC is being developed. Gathering process data includes:

1. Identifying the processes within the system
2. Collecting any documentation about the current processes
3. Determining the chain of command for each process
4. Documenting the processes

Members of the AFRL team visited the University of Arkansas campus to conduct a brief tutorial of high-level Air Force operations. From this tutorial, the need for the team to see and collect information concerning the flightline process was confirmed. The team visited Hill AFB in Ogden, Utah to collect information concerning the USAF general flightline operations. The team was able to observe the entire flightline process from the aircraft launch through all the processes undertaken after its landing to prepare it for another launch. The team conducted briefings with individuals concerning supply, scheduling, and maintenance. From this visit, the team took away a better understanding of the overall process and began identifying key measures used by the USAF for measuring performance of the flightline MX activities.

During the visit, the team identified documents that could be helpful in identifying performance measures. The combination of site visit notes and USAF documents helped the team begin building an exhaustive list of performance measures. At this point, the majority of the process data had been collected and the team was ready to collect the strategic data.

5.1.3.2 Strategic Data

Strategic data is information that can be used to explain the mission statement, vision statement, and core values of an AMU and their daily implementation. This strategic information is imperative to the formulation of the BSC. The analysis of the process data collected from the first site visit allowed the team to focus the project's scope and pointed out the need for strategic data. Process data provided information about the current performance measures in use but not the strategy that the USAF uses to govern these measures. The team understood the basics of the flightline but needed to understand more about the strategic focus of an AMU. A second site visit was scheduled to Barksdale AFB in Bossier City, Louisiana. The main focus of the Barksdale visit was to answer questions concerning the strategic approach of the AMU. Such questions included:

- ◆ Who the customers for the preliminary BSC are
- ◆ What reports are being used to measure performance that the team might not already have
- ◆ What are the most important measures used to assess performance

The team conducted interviews with USAF personnel including the MX Group Commander, the MX Squadron Commander, the MX Squadron Chief Enlisted Manager, and the AMU Production Supervisor (Pro Super). The team's investigation of the strategic approach sought the process improvements that would lead to long-term improvements in specific areas such as the "mission-capable rate" and the total number of "sorties flown." An example of improvements noticed by the team included how an increase in supply chain reliability would lead to a decrease in the frequency of cannibalization actions and a decrease in the MICAP start-to-stop time durations. The team noted that the key customers for the team's preliminary BSC are the operations group, individual aircrews, and USAF higher command. The team was introduced to the 9302 report and presentations during the weekly planning meetings. From this information, the team discovered new possible measures and solidified the importance of others. Some of the measures that stood out from the 9302 forms were the "CANN rate," "maintenance hours per flying hour," "PMCM" and "TNMCM." AFRL personnel provided additional assistance by arranging the site visit, serving as base guides during the visit, and answering post-visit questions.

5.1.3.3 Reference Materials

As stated in *Section 4.1.3.3*, reference materials are published documents that contain information on relevant processes and their performance measurement. The team used documentation provided by the Air Force to enhance the understanding of the operations under observation. The reference materials provided by the Air Force included training and instruction guides (ACCI 21-165, 2000; ACCI 21-118, 2002; AFI 21-101 ACCSUP1-INT, 2003; AFI 36-2201v3, 2002; AFI 36-2232, 1999; HOF reports, 2003;

9302 forms, 2002), and the *Metrics Handbook for Maintenance Leaders* (AFLMA, 2001) to collect process and strategic data. Because the team relied upon the USAF for the majority of the information about its operations, reference materials were collected along with other data throughout the duration of the project.

5.2 Design Stage

5.2.1 Goal Development

In *Section 4.2.1*, goal development is described as the process of turning a developed strategy into attainable long-term goals. This stage is invaluable during the process of developing a working BSC. Because of the external nature of this project, the in-depth knowledge required to formulate long-term goals for the AMU was not available; thus, the team developed these goals based upon assumptions made about the strategy of an AMU. The main goals identified by the team were “to increase the total number of sorties flown in a given period of time” and “to increase the mission-capable rate.”

5.2.2 Objective Identification

Objective identification is described in *Section 4.2.2* as the conversion of strategies and long-term goals into specific timelines and events. For the team, this process consisted of recognizing some of the measures that should be included in the objective perspective, because this is the perspective that drives the BSC. From the strategy developed in *Section 5.1.2* above, the team was able to identify a few key measures to be placed in the objective perspective such as “sorties flown,” “mission-capable rate,” and “maintenance hours per flying hour.”

5.2.3 Perspectives Determination

The perspectives are critical components of a functional BSC. Perspectives provide a central theme for each group of key measures incorporated into the BSC. The underlying strategy should be evident throughout the selection of perspectives. The research team used the information gathered through site visits and USAF documentation to determine the core competencies that drive success for an AMU. These core competencies led the team to inspect how the original business perspectives developed by Kaplan and Norton (1996) could be adapted to the AMU’s structure. The team identified the following four perspectives that were inline with the identified strategy and goals of an AMU and stayed true to the BSC development process:

- ◆ Mission Perspective
- ◆ Management Perspective
- ◆ Internal Enhancement Perspective
- ◆ Influencing Factors Perspective

The original BSC (Kaplan and Norton, 1996) was built around the objective perspective. All improvements should have a positive impact on some aspect of this perspective. Taking this into account, the research team determined that this perspective should reflect the completion of the prime objectives of the AMU: increasing the ability to successfully accomplish missions and the ability to deploy as rapidly as possible. This resulted in the development of the Mission Perspective. The Mission Perspective reflects the productivity of a unit by measuring factors such as:

- ◆ How many units are flown in a given period
How many planes are ready to fly at a given time
- ◆ How efficiently a unit uses its time when compared to its productivity

All other perspectives should in some way improve this perspective. If they fail to do this, they should either be represented in the Mission Perspective, or they are not worthy enough to include in the BSC.

The BSC perspectives can and should be used to represent major stakeholders. One of the major stakeholders of the original BSC is the customer. The customer-related measures are used to measure market share, customer retention, customer acquisition, customer satisfaction, and customer profitability. The “customer” is not necessarily the best indicator for the USAF to use. The major stakeholders in the place of outside customers are the management command. It is the perception of the higher command that is important. Many of the measures they observe deal with efficiency in operating within pre-set standards or schedules. This perspective also reflects the quality of work done. As stated above, each perspective must improve aspects of the Mission Perspective. The Management Perspective indicates the timeliness of work in the Mission Perspective.

Other major stakeholders in the USAF are supply and scheduling personnel. Effective supply and scheduling encompass a vital part of increasing the USAF’s ability to accomplish its mission successfully. Supply is an aspect of operations that has a direct impact on success, but is, however, typically out of the unit’s direct control. Scheduling is similar to supply in that it is not under the control of the AMU. It was observed that while measures in this perspective can be very informative, they should be considered with care. They must not be given undue weight. For this reason, the team developed the Influencing Factors Perspective to include these stakeholders.

Learning and growth are two of the greatest assets of the BSC. Through them, internal investments in training, capital investments in equipment, and building of infrastructure can be linked to financial gains. The Internal Enhancement Perspective is similar to this in that it reflects investments into training and internal quality. Many times it can link indirectly into Mission Perspective through the Management Perspective by increased adherence to or exceeding of pre-set standards. It can also link directly into the Mission Perspective through increased capability and capacity.

The four perspectives developed by the research team—Mission Perspective, Management Perspective, Internal Enhancement Perspective, and Influencing Factors Perspective—should be considered a starting point to developing a BSC for an AMU. These perspectives should be carefully reviewed to assist in developing perspectives for BSCs for use in an actual AMU. The most important aspect of a BSC is the actual development process. Success comes through identifying the key stakeholders and competencies and then exploiting them.

5.2.4 Performance Measure Identification

The final measures included in a BSC are a collection of a specific entity's most important and relevant performance measures. The measures included in the final BSC are chosen through an extensive process. The first step in identifying the measures is to list all possible measures available for examination, and also identify new potential measures. From this now-exhaustive list, the selection process can begin.

The team used the collected documentation and external interviews to identify a comprehensive list of performance measures. The team primarily used three resources to identify these measures: the 9302 forms (2002), the HOF reports (2003), and the *Metrics Handbook for Maintenance Leaders* (AFLMA, 2001). Additional measures were identified by a team member in an interview with a retired USAF General. The team sought additional measures to contribute to the Internal Enhancement Perspective. Most of the measures collected from documentation appeared to fit well within the other three perspectives, but measures for the Internal Enhancement Perspective were more difficult to identify. Some of the measures identified for this perspective include Equal Employment Opportunity (EEO) complaints, Inspector General (IG) complaints, and Special Experience Identifiers.

Each listed performance measure was identified by the team as a measure used by the USAF to gauge an AMU's execution of flightline activities. The comprehensive list created by the team includes the name of

the measure and which, if any, of the three predominately used resources the measure came from. The exhaustive list of performance measures is provided in *Appendix 2*.

5.2.5 Measure to Family Assignment

Once all measures are compiled, families are established and measures are assigned to a specific family. Families are used to organize the list of identified measures into groups based upon the characteristics or objectives of each measure. The team reviewed the exhaustive list of performance measures and assessed the similarities among the measures. The similarities that surfaced became the basis of the created families. The family names and a description of each family are discussed in *Table 5.1*.

Table 5.1: BSC Family Descriptions

Productivity	These are all bottom-line measures that show how well a unit is accomplishing its mission by quantity and quality of its deliverables.
Supply	These are all outside supply measures. These are indirect factors that must be controlled in order to accomplish mission objectives.
Timeliness	These are measures that reflect how well a unit is accomplishing its tasks on time. Its measures also reflect how well a unit completes repairs compared to the average time required for these repairs USAF-wide.
Excellence	These measures reflect the quality of work accomplished by a unit.
Growth	These are measures that reflect the morale of a unit. They also reflect the behavior of its members and show their efforts toward self-improvement.
Scheduling	These are additional measures that show outside influences on an AMU's work. They show how well an AMU complies with the flight schedules and what might be outside their control.

Each measure was then assigned to a family based upon its association with the most appropriate family description. The assignment of each measure and its corresponding family is provided in *Appendix 3*.

Next the team assessed the relationship of each family to the four perspectives. A perspective can have more than one family, but each family cannot be assigned to more than one perspective. *Table 5.2* provides the four perspectives created and each perspective's corresponding family or families. The families serve as attributes for each of the perspectives.

Table 5.2: Perspective to Family Relationship

Perspective	Family
Mission	Productivity
Influencing Factors	Scheduling
	Supply
Management	Timeliness
Internal Enhancement	Excellence
	Growth

5.3 Finalization Stage

5.3.1 Measure Assignment to the BSC

Assigning measures to the BSC is the culmination of all the previous steps. The perspectives and families have been defined, and now is the time to begin selecting the measures that best represent the overall strategy of the AMU. When the team completed the exhaustive list of measures, the number of measures accumulated was close to 90. A typical BSC contains between 20 - 25 measures. The candidate measures were evaluated and eliminated according to their perceived value toward achieving the overall strategy of the AMU and the importance of each measure in accordance to its appearance in USAF documentation. This process was used to create a reduced list of measures that were likely candidates for inclusion in the BSC.

After this initial screening, the remaining measures were evaluated based upon the Caplice and Sheffi (1994) criteria found in *Table 4.1*. By evaluating the measures based upon these trade-offs, the team was able to cultivate a smaller pool of candidates for use in the BSC. Assigning measures to the BSC is not the process that produces the final set of measures. The intention of the process is to establish a set of measures that could be used in the BSC if they succeed through the final stages of the development process.

5.3.2 Correlation Determination

Forming linkages between measures in the BSC creates cohesiveness between the perspectives that allows the organization to maximize the use of the BSC. When strategies are developed, correlations can be produced within the measures of the BSC. Given the external nature of this research and the dynamic nature of the USAF, the team could only hypothesize possible strategies for Air Force success because of the lack of internal process knowledge. The hypothesized strategies were used to develop an example correlation to test the team's example scorecard. The example correlation was based upon the team's experience throughout the project, and was explained in *Section 4.3.2*. This correlation allowed the team to solidify some of the measures to be put into the final BSC.

Correlations should be developed using the firm foundation of strategic knowledge from within an AMU. From an internal perspective, correlations should be extensively evaluated before finalizing the measures in the BSC. The correlations between various measures could greatly affect the success of the BSC. The purpose of the BSC is to tie multiple facets of an organization together; correlations exhibit those ties.

5.3.3 Measure Finalization

The final measures to be included in the BSC will represent the perspectives comprehensively to ensure that an accurate reading of the organization as a whole can be taken. Each measure's definition or function is very important when settling on the final measures (*Table 5.3*). After the correlations are produced, there may be perspectives with fewer measures than anticipated. As was discussed in *Section 4.3.3*, a BSC should contain two different types of measures: strategic and diagnostic. Strategic measures define an organizational strategy. The measures remaining to be assigned after the determination of correlation are likely to be diagnostic. Diagnostic measures monitor whether a process stays in control. Diagnostic measures fill gaps as the measures of the BSC are finalized.

Because of the external nature of the project, the team selected some of the final measures for the preliminary BSC based more upon the collective knowledge of the team than on the correlations produced. The team selected a small portion of the strategic measures from the correlations produced and the other portion based upon the assumptions made about the strategic goals of an AMU. The team filled in the gaps with diagnostic measures such as "CANN rate," "TNMCM," and "total abort rate." For a final AMU BSC, more measures should be finalized through the study of correlations. This would solidify the strategic linkages within the BSC and therefore increase the resulting benefits. The preliminary BSC developed by the team is shown in *Figure 5.1* and the preliminary definitions are shown in *Table 5.3*.

Mission Perspective*- Long-term ability to improve combat capability*

- ◆ Maintenance hours per flying hour
- ◆ MC rate
- ◆ PMCM
- ◆ Sorties flown
- ◆ TNMCM

Influencing Factors Perspective*- Success with collaborators and functional processes*

- ◆ CANN rate
- ◆ MICAP fill rates
- ◆ MSE
- ◆ TNMCS

Management Perspective*- Achievement of customer service*

- ◆ Adherence to OPS/MXS schedule
- ◆ DD rate AWM
- ◆ Total Maintenance deviations
- ◆ 4-hour fix rate
- ◆ 8-hour fix rate
- ◆ 12-hour fix rate
- ◆ Days in Phase/ISO

Internal Enhancement Perspective*- Necessity for innovation and growth*

- ◆ CND rate
- ◆ RR rate
- ◆ Special Experience Identifiers
- ◆ Total abort rate
- ◆ Training schedule adherence
- ◆ Upgrade Training
- ◆ Unit average technical skill level

Figure 5.1: Preliminary BSC for AMU Flightline MX Activities**Table 5.3: Definitions of Preliminary BSC Measures**

Mission Perspective	
Maintenance hours per flying hour	The total number of maintenance hours performed versus the total number of flying hours
MC Rate	The total number of mission-capable hours (fully or partially) versus the total number of possessed hours
PMCM	The number of possessed hours an aircraft is partially mission-capable due to needed maintenance

Mission Perspective	
Sorties flown	The number of sorties flown in a specified period of time (week, month, year)
TNMCM	The number of possessed hours an aircraft is totally not mission-capable due to maintenance
Influencing Factors Perspective	
CANN rate	The number of cannibalization actions versus the number of sorties flown in a given time period (week, month, year)
MICAP fill rate	The time duration or how long the fill process takes for a Mission-Impaired Capability Awaiting Parts aircraft
MSE	The number of maintenance actions started versus the number of maintenance actions scheduled
TNMCS	The number of possessed hours an aircraft is totally not mission-capable due to supply
Management Perspective	
Adherence to OPS/MXS schedule	The number of deviations from the OPS or MXS schedule committed
DD rate AWM	The average number of deferred discrepancies due to maintenance in a given time period (week, month, year)
Total maintenance deviation	The total number of deviations from the maintenance schedule
4-hour fix rate	The percentage of aircraft that return with a Code 3 break and are returned to MC status within 8 hours
8-hour fix rate	The percentage of aircraft that return with a Code 3 break and are returned to MC status within 4 hours
12-hour fix rate	The percentage of aircraft that return with a Code 3 break and are returned to MC status within 12 hours
Internal Enhancement Perspective	
CND rate	The total number of in-flight discrepancies that could not be duplicated by maintenance personnel versus the total number of in-flight discrepancies
RR rate	The number of fixed problems that reoccur versus the total number of fixed problems

Mission Perspective	
Special experience identifier	Special hands-on training or experience an individual receives and is given credit for
Total abort rate	The total number of sorties aborted versus the total number of sorties attempted
Training schedule adherence	The number of deviations from the training schedule committed
Upgrade training	The status of an individual concerning the next upgrade in level of maintenance training
Unit average technical skill level	The cumulative skill level of personnel in a unit per the number of personnel in a unit

Because the BSC was externally produced, validation was an important step in the case study. The team created a questionnaire (presented in *Appendix 4*) that was administered by AFRL personnel to attendees at the 2003 LOA National Conference. This conference was held 13-16 October 03 in Oklahoma City, Oklahoma. The questionnaire sought the expertise of logistics personnel in ranking the criticality of the measures on the preliminary BSC. Additional information about the analysis and results of the questionnaire is provided in *Section 6*.

5.3.4 Ownership Assignment

Assigning ownership of measures to specific individuals is important to the success of a BSC because a single person cannot constantly monitor or be held accountable for all of the BSC measures. Because the team is external and the BSC is not being implemented at this time, ownership assignment was not undertaken. Ownership to particular measures would be assigned by the individual in charge of the entire BSC. Since multiple BSCs are possible within one wing or even one squadron, one individual may own an entire BSC and also use their BSC as a single measure for a higher-level BSC.

5.3.5 Scorecard Cascade

Scorecard cascading is outside the scope of this project. The team did develop one suggestion of a possible opportunity for cascading. The daily and weekly meeting hierarchy would be an excellent way to cascade the BSC. The commander would have the high-level BSC developed by the project team. Each sub-commander would have a scorecard developed with measures cascaded down from measures in the commander's scorecard. The aggregation of each of the sub-commanders' BSCs would form the commander's BSC.

5.3.6 Review and Revision

Review and revision is key to the continued success of a BSC. By reviewing the BSC at scheduled intervals, the opportunity for continuous improvement exists. Within the context of a functioning BSC, the internal team would use the review time as constructive criticism of the current BSC. This is both productive and healthy for an organization. Continuous improvement is imperative to the survival of efficient practices and success as an organization.

6 BSC Validation

The questionnaire discussed in *Section 5.3.3* and presented in *Appendix 4* was used to obtain expert opinions about the hierarchy of the perspectives and measures included in the preliminary BSC. The purpose of this questionnaire was to see if logistics personnel believed that there were more important measures that should be added or current measures that should be omitted. The questionnaire requested each respondent to rank each of the four perspectives in decreasing criticality and rank each measure within the four perspectives by decreasing criticality within their perspective. The rankings used an increasing numeric scale to portray relative criticality: the lower the number, the higher the criticality, with 1 being the most critical. The questionnaire also requested that the respondents suggest any omitted measures that they deemed pertinent.

Thirty-six respondents completed the anonymous questionnaire. Responses from each questionnaire were entered into a Microsoft® Excel spreadsheet. This Respondent Raw Data Spreadsheet is presented in *Appendix 5*. The spreadsheet is divided into three sections corresponding to the information requested on the questionnaire. The first section displays how each individual ranked the four perspectives on a scale of one to four, with one being the most critical and four being the least. The second section contained four parts, displaying how each individual ranked the measures corresponding to each of the four perspectives. The third section displayed the job classification of the respondent.

The questionnaires were examined for completeness and usefulness and a set of criteria was developed to determine possible outliers. Outliers were questionnaires that did not fully conform to the guidelines of the questionnaire. These outlier questionnaires were removed from the study, resulting in 26 viable respondents. The discarded questionnaires were 2, 3, 4, 9, 14, 16, 25, 27, 34, and 35 as shown by the shaded rows of the Respondent Raw Data Spreadsheet. An example of an outlier questionnaire is one where the respondent combined two of the perspectives into one and ranked them using their own method. There were also questionnaires with minor problems such as only three of the four perspectives being ranked or the measures being ranked but not the perspectives that were also discarded.

Next, a count of the times each perspective and each measure within each perspective was assigned a particular ranking of 1, 2, 3, etc. was computed. The corresponding percentage represented the number of times each perspective or measure was given that ranking out of the total number of questionnaires. The percentages allowed the data to be conceptualized in a more meaningful manner.

In addition to the comprehensive results of the respondents as a whole, the results were categorized by respondent job function level where adequate sample size within the category permitted, specifically group-level maintenance supervision/staff and squadron-level maintenance supervision/staff. Of the 26 questionnaires used for analysis, 23 of them fell into one of these two job function levels. The analysis was repeated for each group individually, allowing for observation of how the two levels of job function may differ in their view of the criticality of the perspectives or measures.

The analyzed data from the various groupings is presented in a graphical format in the following sections. The graphs are stacked bar graphs with each column representing a specific perspective or measure. The bars contain the percentages of each ranking (1s, 2s, 3s, etc.) that were obtained by each perspective or measure within its perspective. Separate graphs represent the criticality of the four perspectives and the criticality of each measure within its perspective. *Sections 6.1* and *6.2* respectively present the analyzed results from all questionnaires (26) and the questionnaires categorized by job function level including group-level (10) and squadron-level (13).

6.1 Comprehensive Results

Figure 6.1 presents the summary of the criticality of the perspectives from all 26 viable respondents. The results indicate that the Mission Perspective is the most critical perspective with 62% of the respondents giving it the top ranking (1). From the results, it can be concluded that Management Perspective is the next most critical with 23% of the respondents ranking it as the most critical (1). The least critical perspective is Internal Enhancement Perspective with 62% of the respondents ranking it as the least critical (4). This is an expected finding; as this perspective contains measures that are least tangible and has the most measures that are not currently being tracked by the USAF.

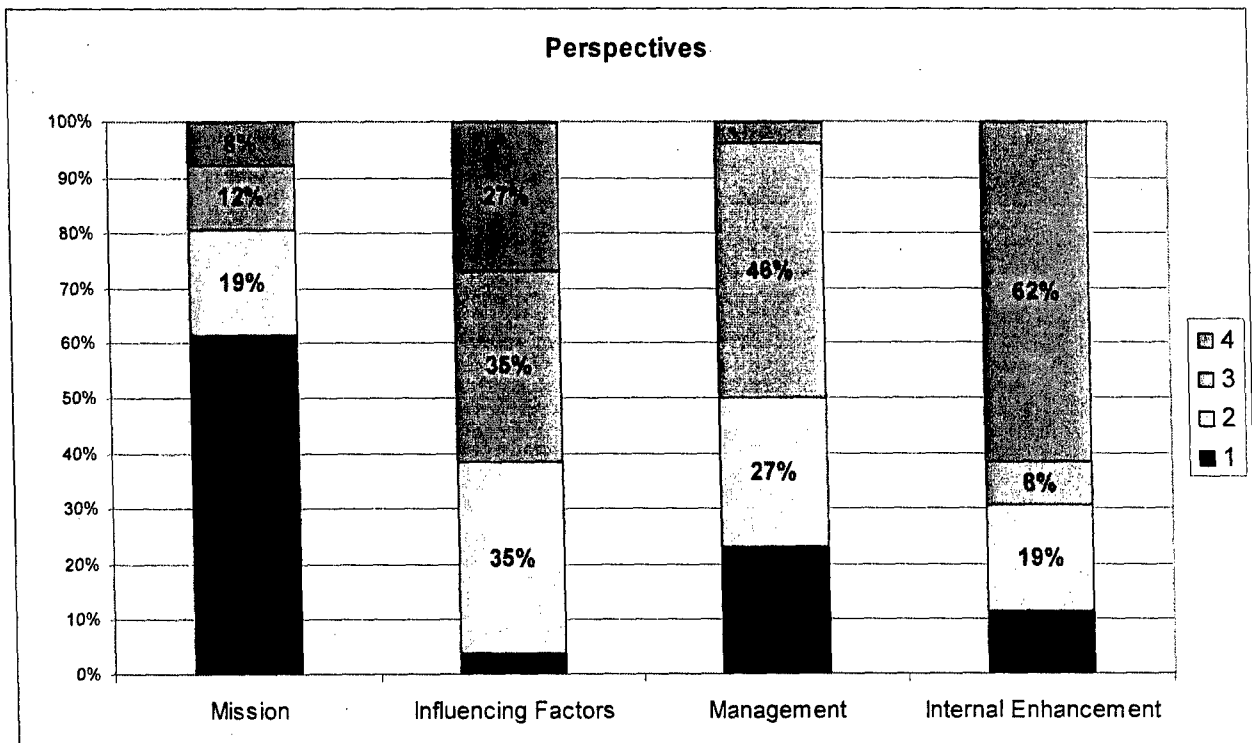


Figure 6.1: Distribution of Responses to Perspectives

Figure 6.2 presents the criticality of the Mission Perspective measures. The measures were ranked on a scale from 1 to 5, with 1 being the most critical measure. The results clearly indicate the “MC rate” is the most critical measure with 58% of the individuals ranking it as the most critical (1). “Maintenance hours per flying hour” measure is the second most critical with 50% of the respondents ranking it as first or second most critical (1 or 2). It is obvious by the graph that “PMCM” is the least critical measure with 58% of the respondents ranking as the least critical (5) and no respondent ranking it as most critical. Based upon these findings, “PMCM” is a strong candidate for removal from the preliminary BSC.

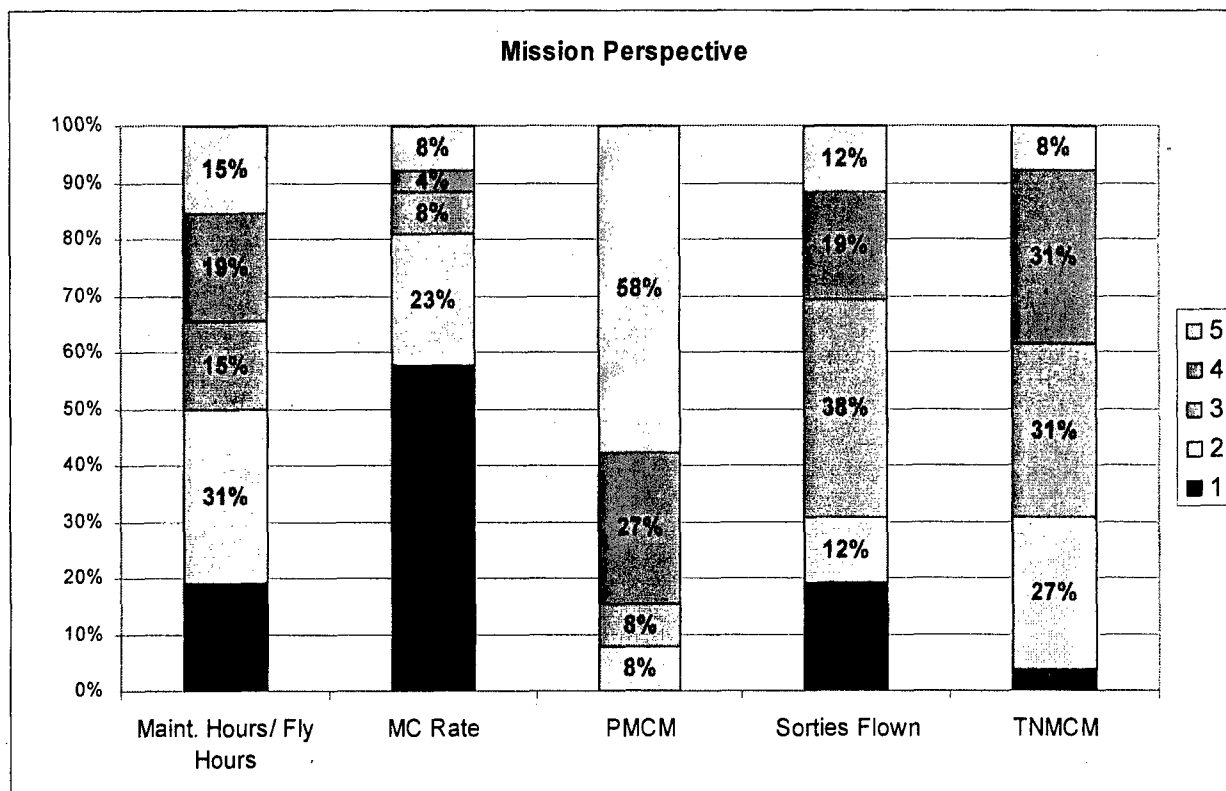


Figure 6.2: Distribution of Responses to the Mission Perspective Measures

Figure 6.3 presents the criticality of the Influencing Factors Perspective measures. The measures were ranked on a scale from 1 to 4, with 1 being the most critical measure. The results indicate the “MICAP fill rate” is the most critical measure with 38% of the individuals ranking it as the most critical (1). The ranking of the other measures in this perspective are less conclusive. Interestingly, “Maintenance Scheduling Effectiveness” has the next highest percentage of respondents (31%) ranking it as most critical (1) and the highest percentage of respondents (50%) ranking it as least critical (4). Respectively 53% and 42% of the respondents rank “CANN Rate” and “TNMCS” as most (1) or second most (2) critical.

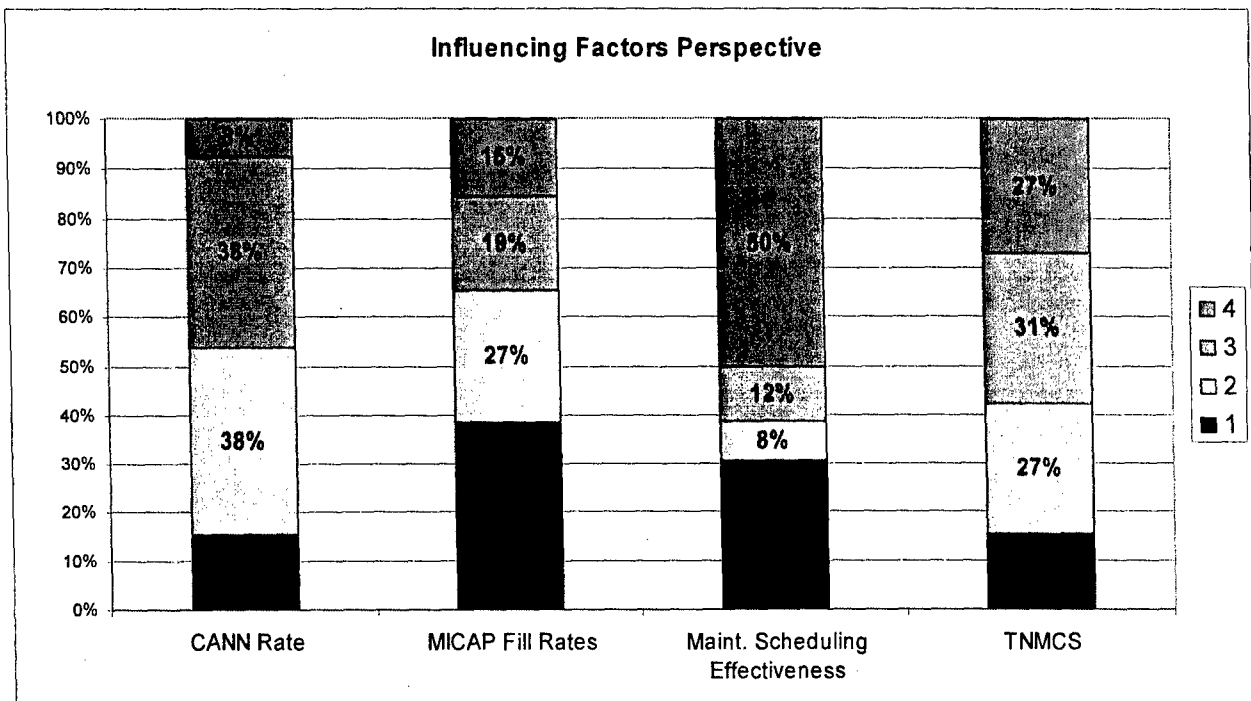


Figure 6.3: Distribution of Responses to the Influencing Factors Perspective Measures

Figure 6.4 presents the criticality of the Management Perspective measures. The measures were ranked on a scale from 1 to 7, with 1 being the most critical measure. The results strongly indicate the “Adherence to OPS/MXS Schedule” is the most critical measure with 58% of the respondents ranking it as most critical (1). The next most critical measure is “Total Maintenance Deviations” with 39% of the respondents ranking it as most (1) or second most (2) critical. The “12-Hour Fix Rate” was deemed more critical than the “4-Hour Fix Rate” and “8-Hour Fix Rate.” Potential measures for removal from the BSC are “DD Rate AWM” and “4-Hour Fix Rate.”

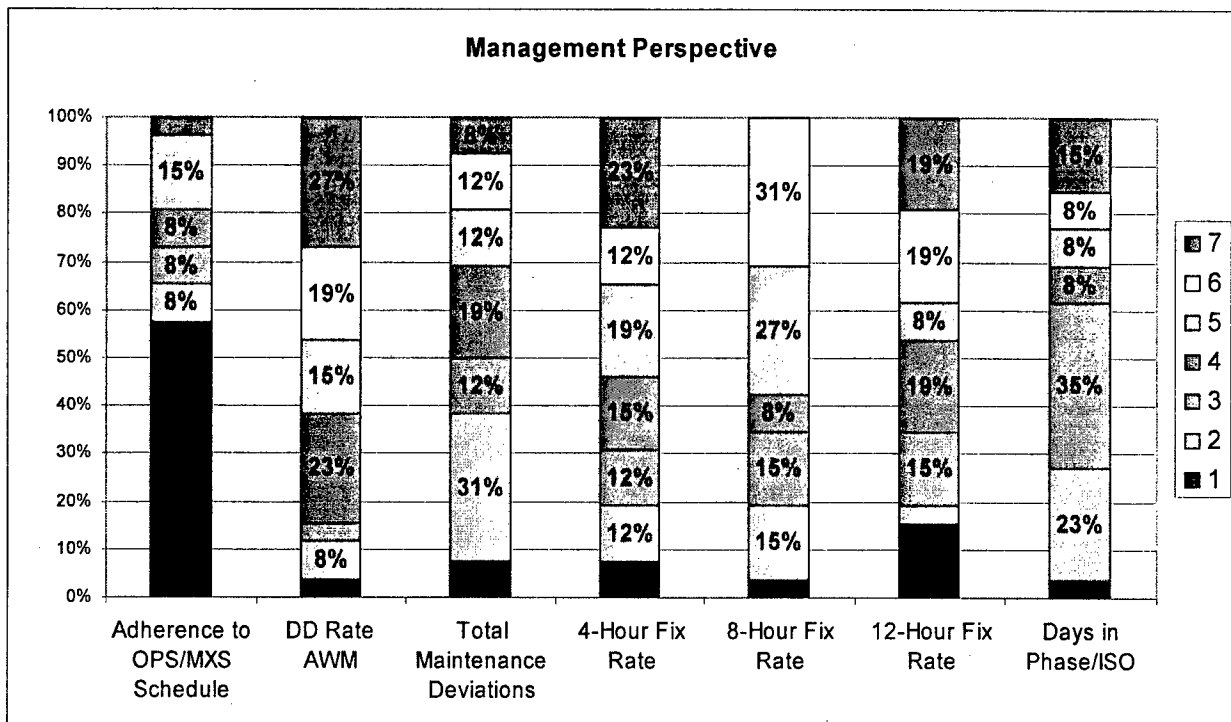


Figure 6.4: Distribution of Responses to the Management Perspective Measures

Figure 6.5 presents the criticality of the Internal Enhancement Perspective measures. The measures were ranked on a scale from 1 to 7, with 1 being the most critical measure. The measure ranking results of this perspective is less conclusive. The results indicate that “CND rate,” Repeat-Recur (RR) Rate,” Upgrade Training,” and “Unit Average Technical Skill Level” are the most critical measures with the greatest number of respondents ranking these measures as most (1) or second most (2) critical. “Special Experience Identifiers” was ranked the least critical (7) with 50%.

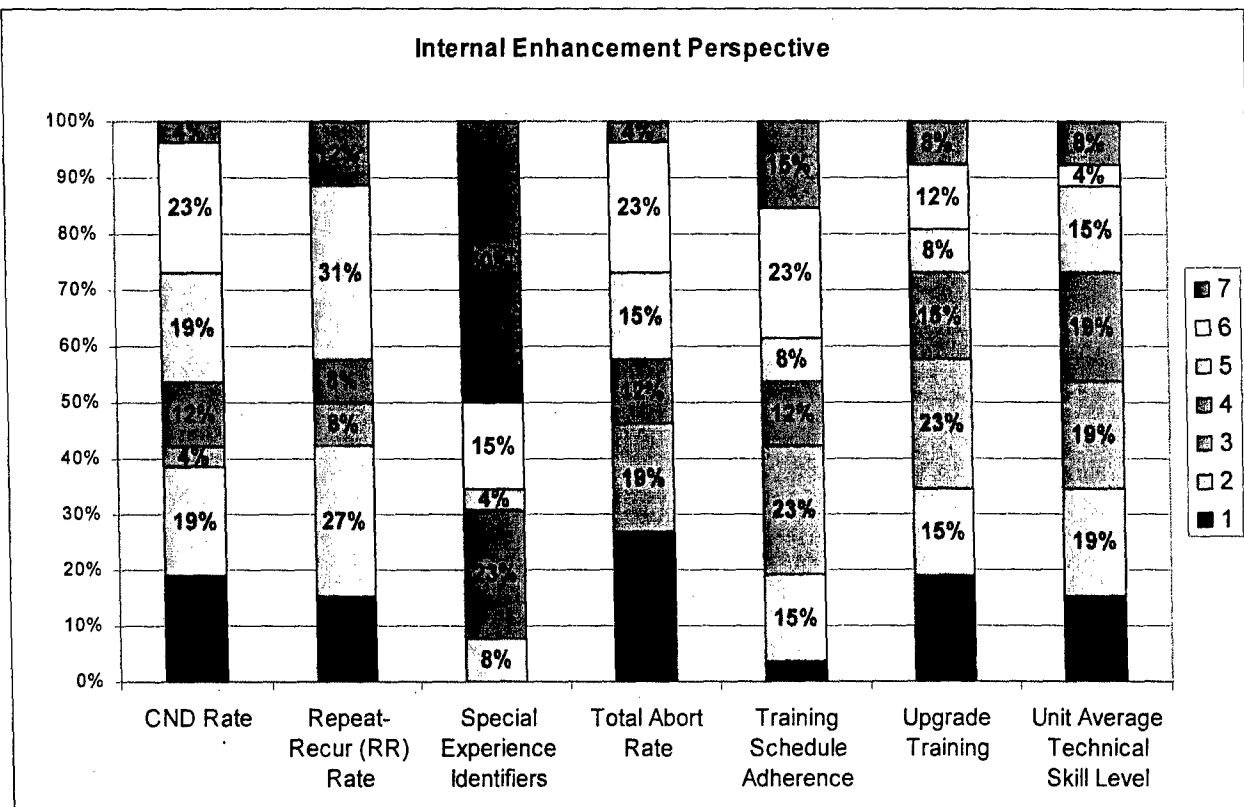


Figure 6.5: Distribution of Responses to the Internal Enhancement Perspective Measures

6.2 Level of Job Function Results

The graphs for respondent rankings by job function level are presented in this section. The majority of the observations are similar to those made in the combined results presented in Section 6.1. Important findings that differ between the two job function levels are noted.

6.2.1 Perspective Rankings

Figure 6.6 and Figure 6.7 present the criticality of the perspectives from the group-level and squadron-level respondents respectively. Both sets of ranking results are similar to the combined ranking shown in Figure 6.1 except for the least critical perspective. Observation of Figure 6.6 shows that Influencing Factors Perspective is the least important perspective for the group-level respondents, while Figure 6.7 indicates that the Internal Enhancement Perspective is least critical for the squadron-level respondents. This result is interesting and supports the cascading of different BSCs for differing levels of the USAF.

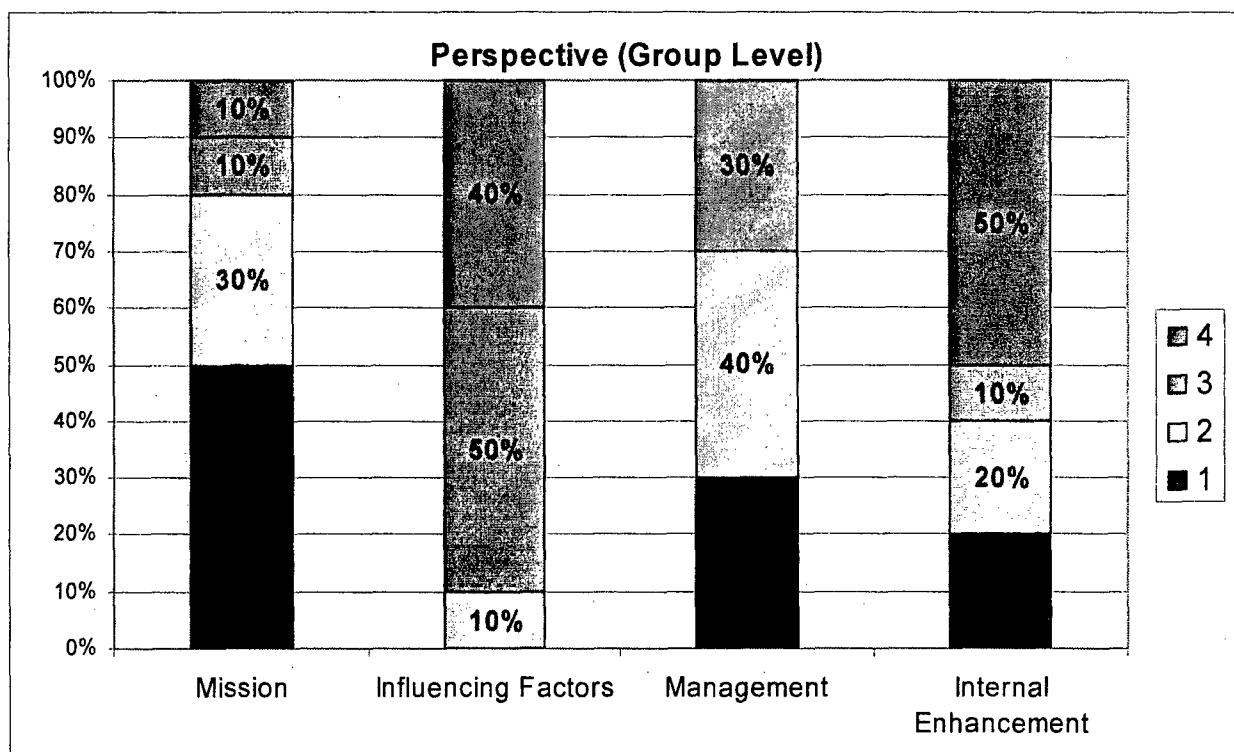


Figure 6.6: Distribution of Group-Level Responses to Perspectives

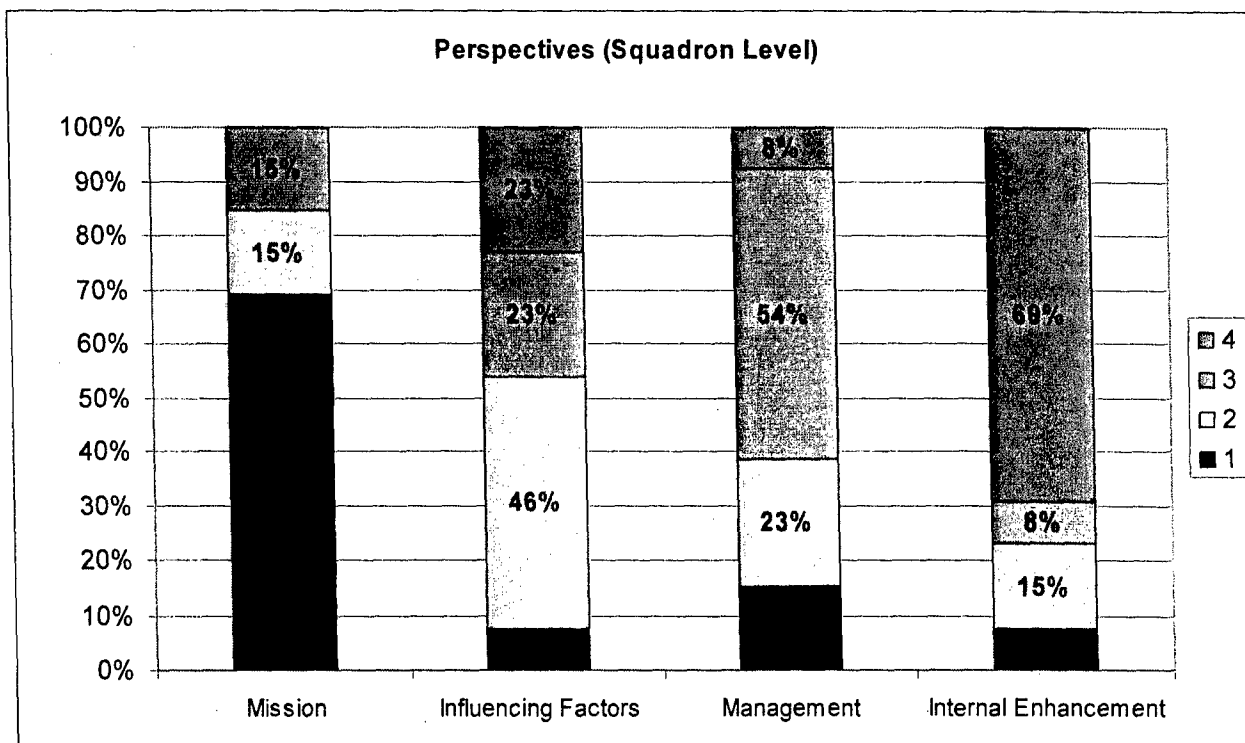


Figure 6.7: Distribution of Squadron-Level Responses to Perspectives

6.2.2 Measure Rankings for the Mission Perspective

Figure 6.8 and Figure 6.9 present the criticality of the measures within the Mission Perspective from the group-level and squadron-level respondents respectively. Both sets of ranking results are similar to the combined ranking shown in *Figure 6.2*.

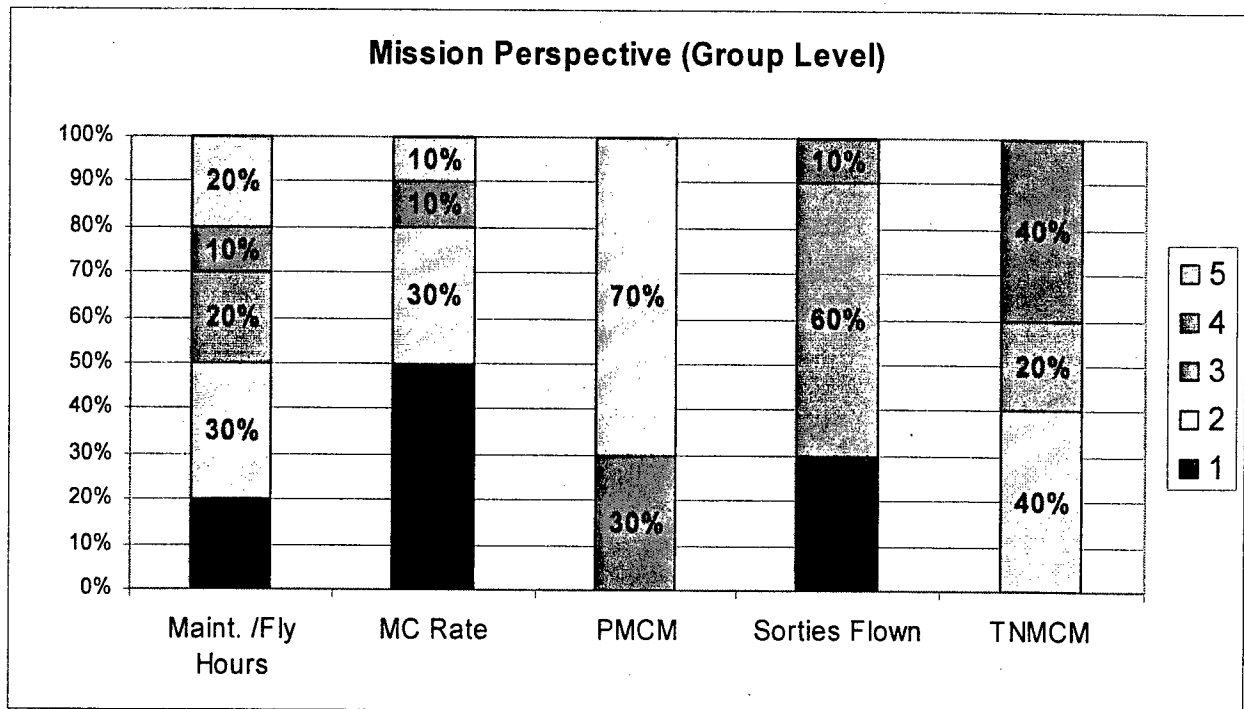


Figure 6.8: Distribution of Group-Level Responses to the Mission Perspective Measures

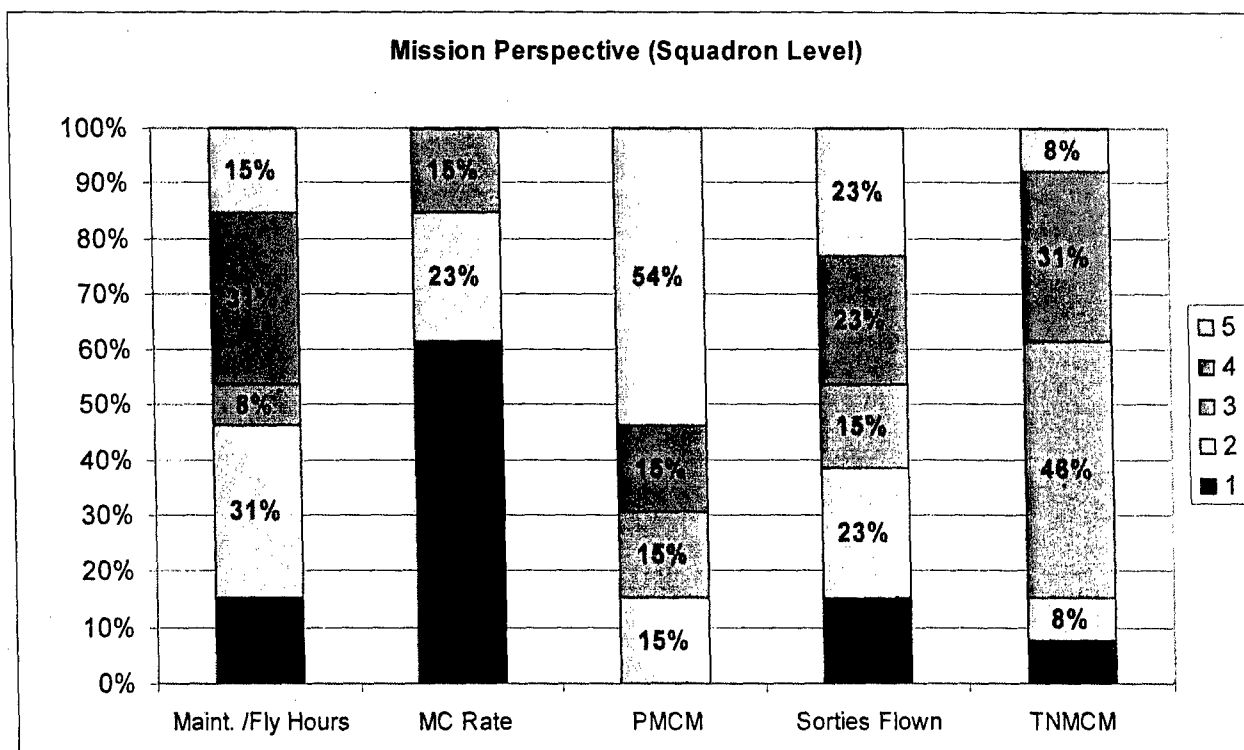


Figure 6.9: Distribution of Squadron-Level Responses to the Mission Perspective

6.2.3 Measure Rankings for the Influencing Factors Perspective

Figure 6.10 and *Figure 6.11* present the criticality of the measures within the Influencing Factors Perspective from the group-level and squadron-level respondents respectively. Both sets of ranking results are similar to the combined ranking shown in *Figure 6.3* except for the ranking of the MSE. This measure has very low criticality for the group-level with 80% of the group-level respondents ranking it least critical (4), but has the second-highest criticality for the squadron-level respondents.

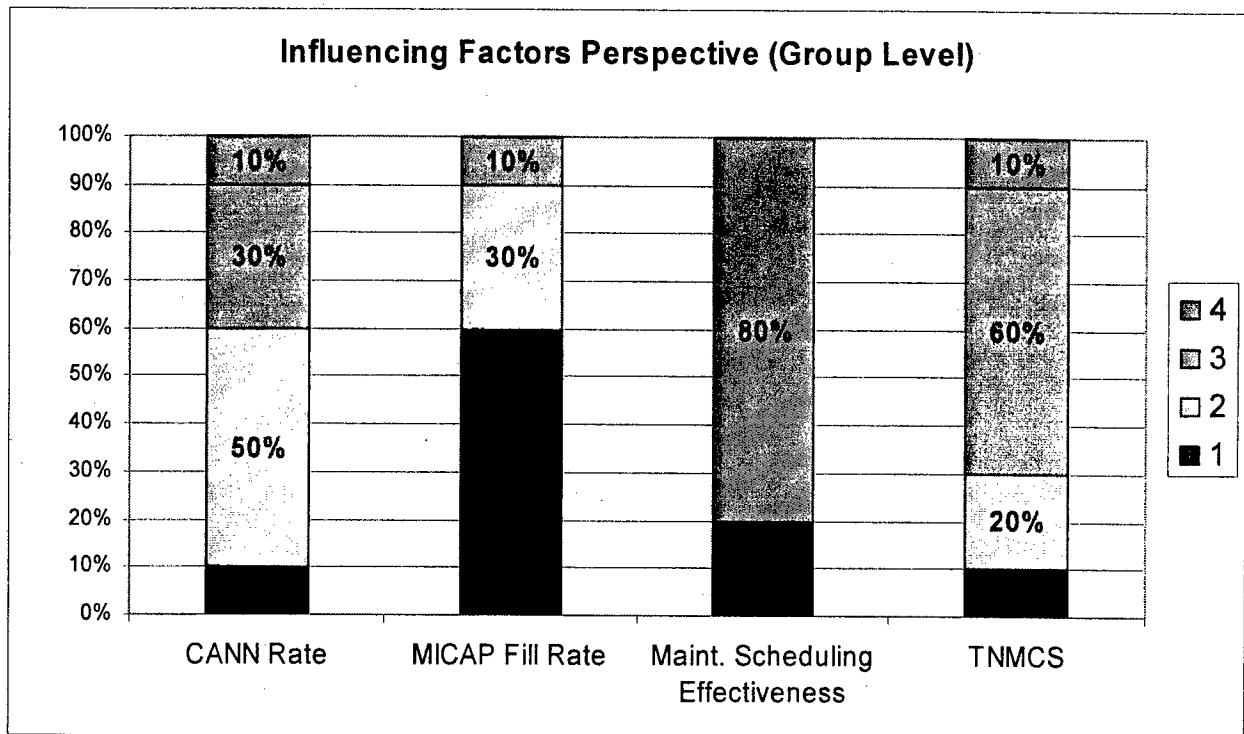


Figure 6.10: Distribution of Group-Level Responses to the Influencing Factors Perspective Measures

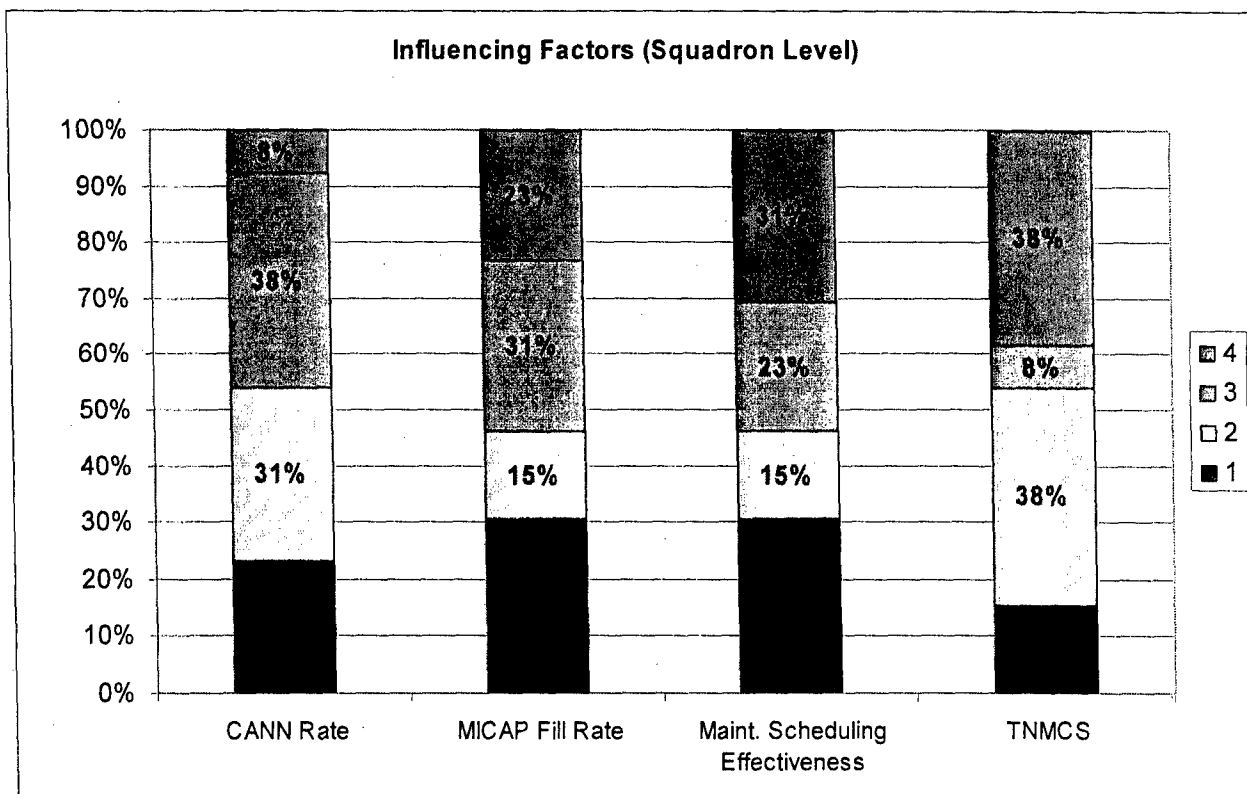


Figure 6.11: Distribution of Squadron-Level Responses to the Influencing Factors Perspective Measures

6.2.4 Measure Rankings for the Management Perspective

Figure 6.12 and Figure 6.13 present the criticality of the measures within the Management Perspective from the group-level and squadron-level respondents respectively. Both sets of ranking results are similar to the combined ranking shown in *Figure 6.4*.

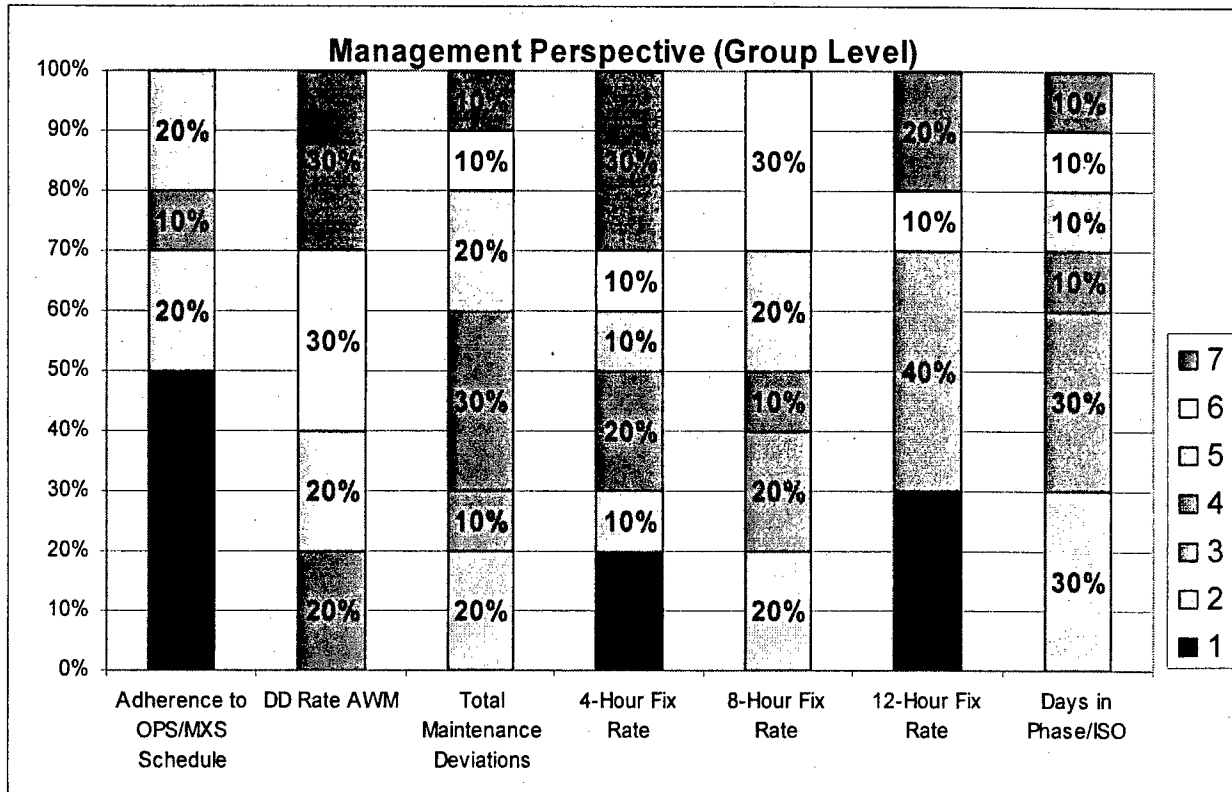


Figure 6.12: Distribution of Group-Level Responses to the Management Perspective Measures

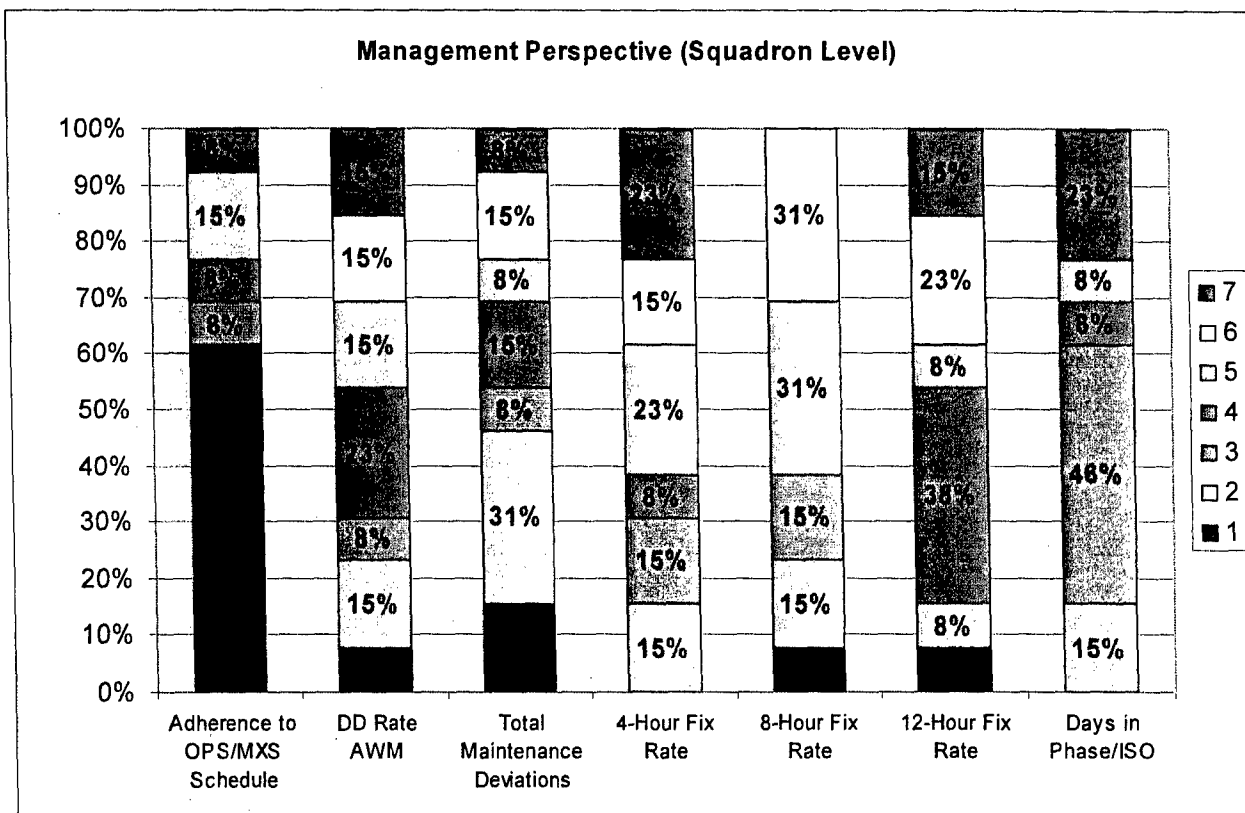


Figure 6.13: Distribution of Squadron-Level Responses to the Management Perspective Measures

6.2.5 Measure Rankings for the Internal Enhancement Perspective

Figure 6.14 and *Figure 6.15* present the criticality of the measures within the Internal Enhancement Perspective from the group-level and squadron-level respondents respectively. The sets of ranking results differ from the combined ranking shown in *Figure 6.5* in their assignment of the most critical measures. *Figure 6.14* shows that the most critical measures for the group-level respondents are “Repeat-Recur (RR) Rate” and “Unit Average Technical Skill Level” similar to the combined results in *Figure 6.5*. The squadron-level results shown in *Figure 6.15* indicate the most critical measures as “Total Abort Rate” and “Upgrade Training.” These differences again support the use of different BSCs for differing levels of job functions.

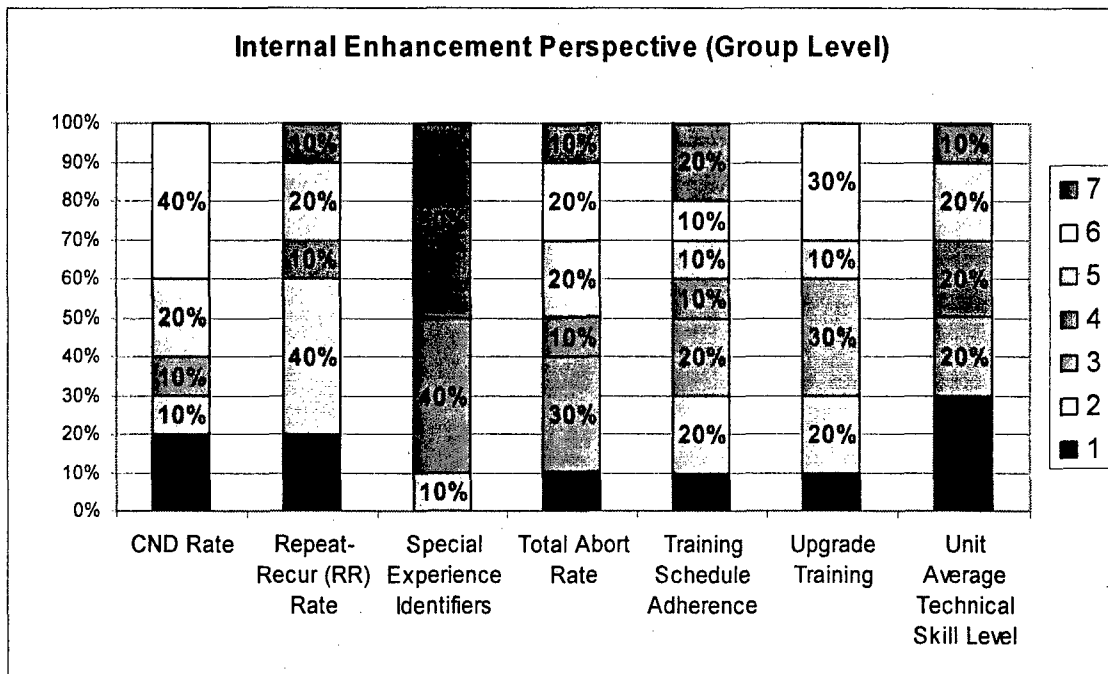


Figure 6.14: Distribution of Group-Level Responses to the Internal Enhancement Perspective Measures

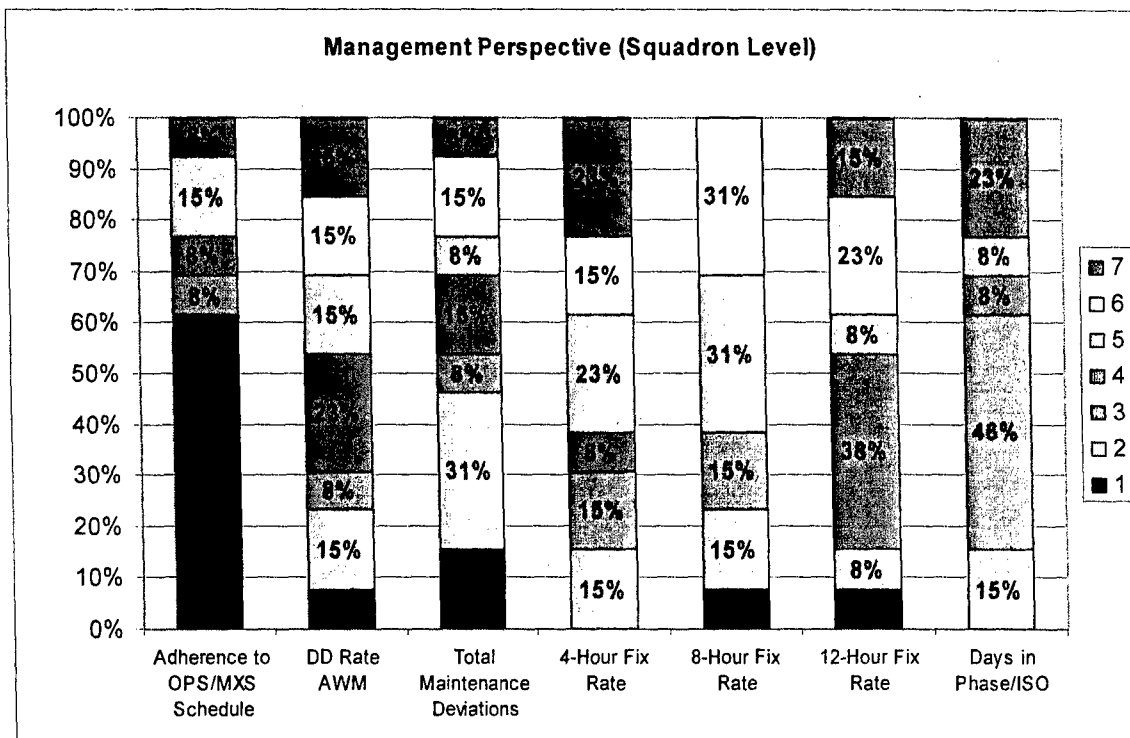


Figure 6.15: Distribution of Squadron-Level Responses to the Internal Enhancement Perspective Measures

7 BSC Software Package Review

7.1 BSC Software

This section discusses BSC software, including standards for the selection and a detailed review of three software packages. Through the BSC, strategies are mapped and monitored. The BSC allows management to keep track of lagging and leading indicators to indicate the success and failure of these strategies. The BSC facilitates cascading of these strategies throughout an entire organization. In order to successfully accomplish this, many different variables must be monitored and communicated to a variety of stakeholders. It is useful for these stakeholders to have these variables visualized in the format of a BSC. The management and presentation of this extensive information is the primary reason BSC software packages have been developed.

7.2 Standards for the Software

There are many BSC software packages available on the market, but limited standards by which to compare them. The Balanced Scorecard Collaborative, Inc. (BSCol) is a firm that was founded by Kaplan and Norton, creators of the BSC, to increase awareness and use of the BSC. The BSCol developed a set of standards to assist end-users and developers of BSC software packages in assuring that their software packages make full use of the BSC. The complete functional standards documentation provided by the BSCol is provided in *Appendix 6*. The stated purposes of these standards are:

- ◆ To provide guidance to user organizations in their evaluation and selection of a BSC software package
- ◆ To help define development guidelines for software companies seeking to support the Kaplan and Norton BSC methodology

7.3 BSCol Functional Standards

The BSCol suggests four categories of features that should be included in the BSC software packages:

- ◆ Design
- ◆ Strategic Education and Communication
- ◆ Business Execution
- ◆ Feedback and Learning

The BSCol considers these as the minimum necessary features, and many software packages go beyond them. A comprehensive discussion of these categories is located in *Section 7.4*.

7.3.1 Design

The BSCol suggests the following features for the Design category:

- ◆ View strategy from the four perspectives
- ◆ Identify strategic objectives for each perspective
- ◆ Associate measures with strategic objectives
- ◆ Link measures in cause-and-effect relationships
- ◆ Assign targets to measures
- ◆ List strategic initiatives

7.3.2 Strategic Education and Communication

The BSCol suggests the following features for the Strategic Education and Communication category:

- ◆ Enable users to document and communicate descriptions of objectives, measures, targets, and initiatives

7.3.3 Business Execution

The BSCol suggests the following features for the Business Execution category:

- ◆ Explicitly show the relationship between initiatives required to achieve strategy

7.3.4 Feedback and Learning

The BSCol suggests the following features for the Feedback and Learning category:

- ◆ Measure results against targets
- ◆ Rely on objective and subjective judgments, for example, do not overrule the judgment of the senior executive
- ◆ Have graphical indicators of performance

7.4 Available Features

During the software review, important features were identified by the research team. These features ranged from network compatibility to user ease and friendliness. The presence of these features in each of the three software packages was assessed through review of manufacturer specifications. The effectiveness of these features was not tested. The most prominent features including networking, interface, assessment capabilities, and options are discussed next.

7.4.1 Networking Features

- ◆ *Client/Server Support* – Software package can be used over an intranet.
- ◆ *Cross Platform Support* – Software package has the capability to use additional operating systems other than Windows®, such as UNIX® or Mac®.
- ◆ *Integration capabilities w/ existing software* – Software package can use data from existing data collection software such as Online Transaction Processing (OLTP) or Enterprise Resource Planning (ERP) systems, data warehouse systems, and others. This feature is very important to quick integration of the BSC.
- ◆ *Real-Time Update of Information* – Information is updated instantly instead of at the end of a day or week, for example
- ◆ *Web support* – A web-supported package that can be accessed via an Internet connection.

7.4.2 Interface

- ◆ *Graphical User Interface (GUI)* – Software package uses a Windows® style point-and-click interface.
- ◆ *Graphs and Trends* – Graphs and trends can be used to describe measures.
- ◆ *Notes for Measures and Initiatives* – Software package has the option to enter notes, descriptions, reasons for actions, or any other pertinent information that assists in understanding measures or strategic initiatives. These appear with the measures on the BSC.
- ◆ *Personal Scorecard* – Each person involved in the BSC can have a personal scorecard that focuses only on the measures over which they have ownership.
- ◆ *Report-Making Wizard* – Software package includes programs to help take the information from the software package and create hardcopy reports.
- ◆ *Scorecard Construction Wizard* – Software package includes programs or macros that help users construct their own scorecards without extensive knowledge of the BSC.
- ◆ *Status Warning for Measures* – Software package sends warnings whenever a measure leaves acceptable parameters. Examples of warnings are color-coded indicators and e-mails to the owner of the measure.
- ◆ *Strategic Themes* – Strategy is depicted on-screen within the software package to easily observe how measures and initiatives apply to it.
- ◆ *Wizard to Install New Measures* – Software package helps the users to implement new measures without vendor assistance or extensive training. Packages with this feature are more robust and can adapt easily.

7.4.3 Assessment Capabilities

- ◆ *Drill-Down Capability* – Features let a higher-level scorecard break down its aggregate measures into lower-level measures. This is useful in locating problem measures that are outside their acceptable parameters.
- ◆ *Milestone Markers* – Milestone markers show the progress toward achieving long-term goals.
- ◆ *Quantitative Analysis* – Software package has the capability to perform statistical analysis on information received from the measures, such as averages and trends, for example.
- ◆ *Show Cross-Linkage of Measures* – Software package shows the interrelations that exist between measures.

7.4.4 Options

- ◆ *Access Control According to User* – This restricts users from accessing measures outside their responsibility or measures that are higher up the scorecards.
- ◆ *E-mail Integration* – There is an integrated e-mail system to deliver messages about measures, notes, or other BSC-related information.
- ◆ *Excel Capabilities* – Measures can be integrated into Microsoft® Excel spreadsheets for further analysis.
- ◆ *Security Features* – These are features such as user login, network encryption, and other features that protect the data in the scorecard.

7.5 Selected BSC Software Package Comparison

As previously mentioned, three BSC software packages, ActiveStrategy Enterprise™, SPImpact, and pbviews, were examined and compared. A brief description of each software package is provided in this section. In addition, the matrix in *Table 7.1* is presented to summarize the features of each software package. The criteria used to evaluate the software packages include the BSCol standards, the features described in *Section 7.4*, and team judgment. This matrix shows that pbviews contains all the preferred features.

7.5.1 ActiveStrategy Enterprise™

ActiveStrategy releases several versions of their BSC software package. These range from a basic scorecard edition to their Enterprise edition with full functionality of all features. For these comparisons, the Enterprise edition was examined.

ActiveStrategy Enterprise™ focuses on measure ownership with personal scorecards to help each person keep track of his or her own measures. It also implements security features so that each person only has access to information relevant to his or her job. It features drill-down capability to help divide aggregate measures for analysis. In order to facilitate organization and focus, it sends relevant reminders and warnings to measure owners.

ActiveStrategy Enterprise™ claims to be a “ready out of the box” package. ActiveStrategy states it can be fully implemented on the most sophisticated systems within eight to 12 weeks. Several integration packages are included to help ensure total compatibility. The system can work over an intranet and/or Internet. Contact information for ActiveStrategy is provided in *Appendix 7*.

7.5.2 SPImpact

Open Ratings claims their SPImpact BSC software package completely follows the traditional BSC methodology. It supports all basic BSC features, including drill-down capability, milestone markers, multiple scorecards, and quantitative analysis. It also supports prioritizing of initiatives, performance tracking, and display of interdependencies among units.

SPImpact employs integration software for most data sources. It also integrates with company e-mail systems to send assessments, reminders, and alerts. SPImpact includes development wizards for scorecards and automated system maintenance and updating.

SPImpact has an out-of-the-box set-up, which helps reduce initial set-up time. The software package includes security features such as enrollment and user privileges. This allows for the creation and maintenance of multiple scorecards. Contact information for Open Ratings is provided in *Appendix 7*.

7.5.3 pbviews

Panorama Business Views has a performance measurement software package called pbviews. pbviews supports a broad range of performance initiatives including the BSC. Their software package is compatible with most measurement systems and existing software. For those that are not directly compatible, pbviews employs a translating system.

The research team took part in a presentation by a Panorama Business Views sales representative.

pbviews has a user-friendly interface. Each BSC measure has a range of descriptions including ownership (the person in charge of the measure), notes, strategic goals, and the ability to look back over time to find

trends. pbviews supports the drill-down function (the ability to go down through each measure to see its aggregates). It was not apparent whether linkages could be formed between different measures and perspectives.

The software package is deployable over an intranet, Internet, or both. The administrator has the option of restricting access to measures according to the ownership of the measure. pbviews allows direct input of results by authorized users. Contact information for Panorama Business Views is provided in *Appendix 7*.

Table 7.1: BSC Software Comparison Matrix

Features	BSC Software Packages		
	ActiveStrategy Enterprise™	SPImpact	pbviews
Network			
Client/Server support	X	X	X
Cross-platform support	X	X	X
Integration capabilities w/existing software	X	X	X
Real-time update of information	X	X	X
Web support	X	X	X
Interface			
Graphical user interface	X	X	X
Graphs and trends	X	X	X
Notes for measures and initiatives	X	X	X
Personal scorecard		X	X
Report-making wizard	X	X	X
Scorecard construction wizard	X	X	X
Status warnings for measures	X	X	X
Strategic themes	X	X	X
Wizard to install new measures		X	X

Features	BSC Software Packages		
Network	ActiveStrategy Enterprise™	SPImpact	pbviews
Assessment Capabilities			
Drill-down capability	X	X	X
Milestone markers	X	X	X
Quantitative analysis	X	X	X
Show cross-linkage of measures	X	X	X
Options			
Access control according to user	X	X	X
E-mail integration	X	X	X
Microsoft® Excel capabilities		X	X
Security features	X	X	X

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Appendix 1: Flightline Maintenance Process

(Excerpted from Flightline Orientation Briefing, 10 March 2003)

Aircraft Landing

The beginning of the maintenance process starts when an aircraft returns from a mission. The table below describes the events involved.

Event	What Happens
Aircraft returns from a mission	Before the aircraft lands, the aircrew may relay aircraft or system discrepancies by radio to the flightline. The aircrew generally converts these discrepancies into a series of standard quick-reference codes to expedite transmission and to allow better understanding of the nature of the discrepancy.
Final landing preparations	Maintenance personnel begin to prepare for the aircraft landing. Maintenance specialists are identified to work reported in-flight discrepancies.
After landing	The aircraft taxis to or near its designated parking location. For some aircraft, the aircrew may refuel at a fuel pit before taxiing to the assigned parking location.
Parking	Once at the parking location, the aircrew may power down systems and engines. In the event of an Integrated Combat Turn (ICT), the aircrew may keep certain systems and engines running as maintenance personnel prepare the aircraft for an immediate launch. A complete discussion of ICTs and Quick Turns is found later in this chapter.
Aircrew departure	Once the aircraft systems and engines are off, the aircrew departs the aircraft. In some cases, the aircrew will discuss discrepancies with the maintenance specialist at the aircraft. Doing so provides the maintainer more detailed information as to the nature of the discrepancy than would otherwise be available. The aircrew should record all noted in-flight discrepancies in the Aircraft Forms before departing for aircrew debriefing. An aircraft forms binder is normally taken to aircrew debriefing. Maintenance personnel begin their work once the forms are returned to the aircraft.

Parking and Recovery

During this phase, the aircraft is “safed” for ground operations and parked at its designated location.

Though the sequence of events may vary for different types of aircraft, the basic process is the same:

- ◆ Landing gear pins are immediately installed to prevent the gear from inadvertent collapse;
- ◆ Grounding wires are installed, and aircraft systems, gun systems, and munitions are “safed”;
- ◆ Engine oil samples are taken for spectrometric examination;
- ◆ Aircraft circuit breakers are set, streamers placed, and protective covering positioned;
- ◆ If necessary, the aircraft is towed to its designated parking location, where servicing actions begin

Aircraft Servicing

Aircraft servicing actions typically include checking system fluid levels and lubrication. The most common fluids requiring servicing include engine oil, hydraulic fluid, and fuel. The next scheduled mission generally dictates fuel loads; however, if this information is unavailable, the fuel tanks are filled to a designated minimum “Ramp” load. Safety is paramount during any fueling/de-fueling operation. While servicing actions take place, the aircrew is debriefed.

Aircrew Maintenance Debriefing

An aggressive aircrew maintenance debriefing program is essential to the maintenance process to ensure accurate reporting and documentation of aircraft malfunctions. The debriefing session is the cornerstone for the entire maintenance documentation process; it documents historical data for identification of repeat and recurring discrepancies to assist in troubleshooting and correcting malfunctions. Documentation systems used by the debriefing section include Core Automated Maintenance System (CAMS), G081 (CAMS for Airlift), Tactical Interim CAMS/REMIS Reporting System (TICARRS), or Computerized Fault Reporting System (CFRS).

Debriefing is normally conducted at the end of each sortie or abort. Maintainers use debriefing to document in-flight discrepancies, aborts, in-flight emergencies, flying time information, Event History Recorder readings, Operational Check Flights, Functional Check Flights, and munitions drops.

The debriefer should properly identify and document repeat or recurring discrepancies, as well as landing status, system capability, deviation, and system fault codes.

Repeat/Recurring Discrepancies

During the debriefing process, in-flight discrepancies are reviewed to ensure they are identified as a repeat or a recurrence when necessary. A repeat discrepancy is one that occurs on the next attempted sortie after corrective action is complete. Generally, a recurring discrepancy is one that is complete, although this may differ by command.

Land Status Codes

Aircrew and maintainers use landing status codes to indicate aircraft status upon landing. The table below lists these codes.

Code	Description
1	Aircraft mission capable with no additional discrepancies
2	Aircraft or system has minor discrepancies but is capable of further mission assignment within normal turnaround times
3	Aircraft or system has major discrepancies in mission-essential equipment that may require extensive repair to replacement prior to further mission assignment. The discrepancy may not affect safety-of-flight and the aircraft may be Not Mission Capable (NMC) flyable
8	Aircraft or system has suspected or known radiological/biological contamination

System Capability Codes

These codes indicate system or subsystem capability at the end of a sortie. The table below describes these codes.

Code	Description
0	System flown with a known discrepancy, no additional discrepancies noted, system can be used
1	System used and performed satisfactorily, no maintenance required
2	System used and performed satisfactorily. A minor malfunction exists, but system is capable of further mission assignment
3	System performance was unsatisfactory, this system did not cause an abort
4	System performance was unsatisfactory, this system caused or contributed to an abort
5	System out of commission prior to takeoff

Code	Description
6	System installed but not used
7	System not installed
8	Aircraft or system has suspected or known radiological/biological contamination

Deviation Codes

The codes in the table below indicate the type of deviation that affect the flying schedule.

Code	Description
AA	Air Abort
AD	Add
AI	Air Abort/In-Flight Emergency
CX	Cancellation
DE	Delay
EL	Early Landing
ET	Early Takeoff
FE	IFE
FI	In-Flight Incident
GA	Ground Abort
LL	Late Landing
LT	Late Takeoff
SL	Subsequent Late
SP	Spare
SX	Subsequent Cancellation
TS	Tail Number Swap

Operation Deviation Cause Codes

The codes in the table below indicate the reason for a deviation or the agency that caused a deviation to the flying schedule.

Note: The first two positions are constant, but the complete codes vary among major commands (MAJCOMs). The "x" denotes any character for local use.

ATx	Air Traffic
COx	Contractor
HQx	Higher Headquarters
MTx	Maintenance
OPx	Operations
OTx	Other
SFx	Material, Safety of Flight
SYx	Sympathy
SUx	Supply
TRx	Tanker/Receiver Deviation
WXx	Weather
xxx	Local Option

System Fault Codes

System fault codes exist for aircraft using fault reporting and fault isolation manuals. These codes help maintainers gain access to correct fault isolation procedures. The codes vary depending on the malfunction. The CFRS, if available, uses software that automates the identification of system fault codes.

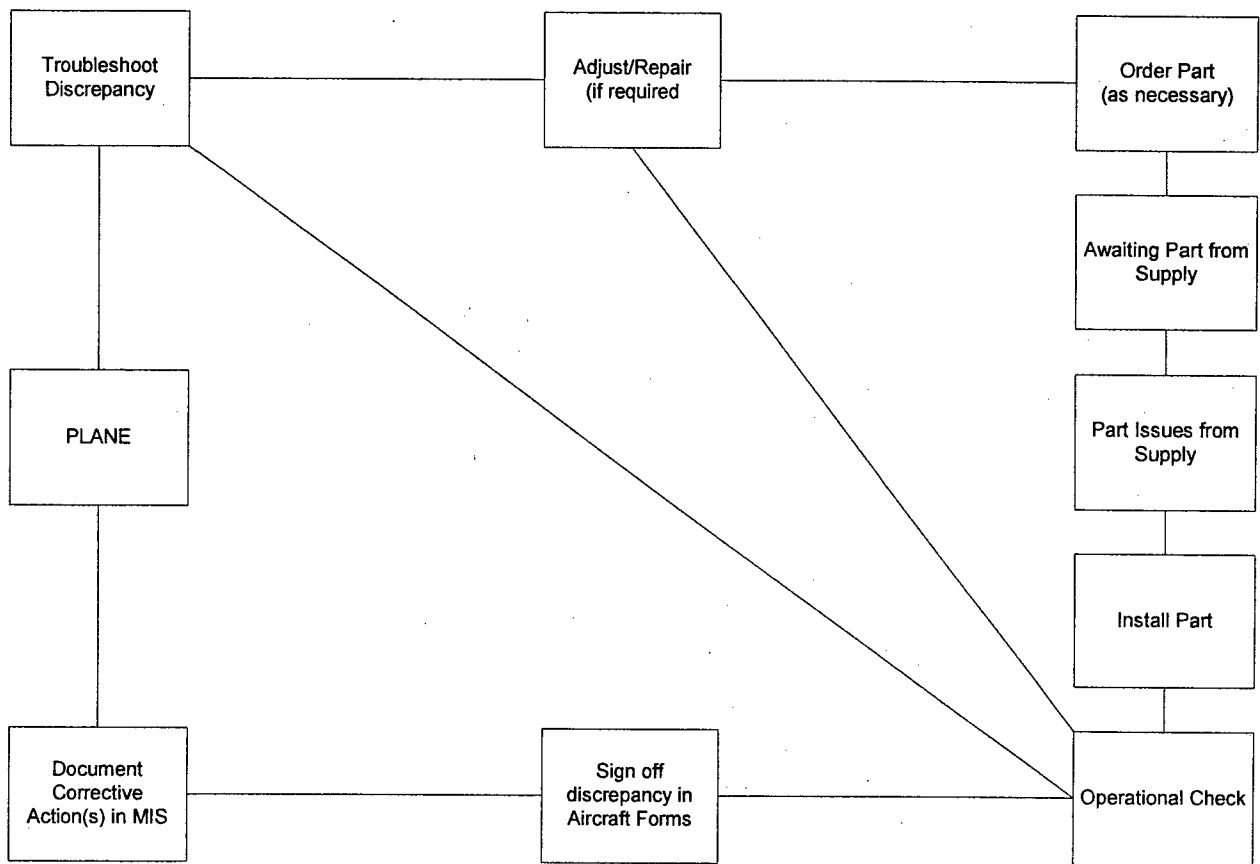
Post-Flight Inspection

After flight, an aircraft will undergo a Thru-Flight Inspection, a Basic Post-Flight Inspection, or a Combined Pre-Flight/ Basic Post-Flight or Pre-Flight/Thru-Flight Inspection. The following table describes some of these inspections.

Type Inspection	Description
Thru-Flight	The Thru-Flight Inspection is a between-flights inspection accomplished after each flight when a turn-around sortie or continuation flight is scheduled and a Basic Post-Flight Inspection is not required. This inspection consists of checking the aircraft for flight continuance by performing visual examination or operational checks of certain components, areas, or systems to assure that no defects exist, which would be detrimental to further flight.
Post-flight	The Basic Post-Flight inspection occurs after the last flight of a specified flying period. This inspection will consist of checking the aircraft condition by performing visual examination or operational checks of certain components, areas, or systems to assure that no defects exist that would be detrimental to flight. It is a more thorough check than the Pre-Flight or the Thru-Flight Inspections.
Combined	The Combined Pre-Flight/Basic Post-Flight Inspection or Pre-Flight/Thru-Flight Inspections consolidates the requirements of the Pre-Flight and Basic Post-Flight Inspections into a single inspection accomplished at the end of the flying period. It eliminates duplication of inspection items and is valuable during periods of high aircraft generation rates.

Unscheduled Maintenance/Repair

During this phase of the process, maintenance technicians start work on the in-flight discrepancies reported by the aircrew. The figure below and the accompanying table illustrate and explain the process for completing unscheduled maintenance actions.



Action	Description	
Identify discrepancy	Once a discrepancy is identified, the aircraft crew chief requests <ul style="list-style-type: none">♦ troubleshooting♦ ordering parts (if needed)♦ determining whether munitions can be "safed" or downloaded♦ adjustment/repair♦ operational checks♦ aircraft forms and Maintenance Management Information System (MMIS) documentation	
Work discrepancy	Once the technician troubleshoots the discrepancy, he or she faces three alternatives: <ul style="list-style-type: none">♦ If the technician cannot duplicate the discrepancy and has exhausted all possible courses of action, he or she clears the discrepancy by indicating "cannot duplicate" (CND) in the aircraft forms and the MMIS. CND actions are a last resort and are coordinated through the Expediter and Production Superintendent.♦ The system or subsystem may require adjustments or repair action that does not require a replacement part. Once corrective actions and operational checks are complete, the technician clears the discrepancy by indicating the corrective actions in the aircraft.♦ The technician may need to change a system or subsystem part or Line Replaceable Unit (LRU). Once the technician identifies which part requires replacement, the technician orders it.	
	If	Then
	The part is available in base supply	It is issued to the technician and installed on the aircraft
	The part is not available	<ul style="list-style-type: none">♦ The part is backordered♦ The Production Superintendent is notified of the backorder status and asked to establish an order priority♦ The repair effort for the discrepancy is placed on hold until the required part arrives through the base♦ In certain cases, cannibalization procedures may supply the part
When the part is available	<ul style="list-style-type: none">♦ It is issued to the technician and installed on the aircraft♦ Operational checks are performed on the system and subsystem♦ The job is completed and signed off in aircraft forms	

Preventive Maintenance

Preventive maintenance includes all scheduled maintenance actions performed to retain the aircraft and its systems in mission-ready condition. Scheduled maintenance involves the accomplishment of periodic inspections, condition monitoring, Time Compliance Technical Orders (TCTO), Time Change Item (TCI) replacements, and system calibrations. The maintenance schedule controls preventive maintenance activities. Close coordination between the production superintendent, flight chiefs, aircraft schedulers, and the support flight ensures all necessary resources are available to perform the job. These resources include the aircraft, manpower, parts, and equipment.

The Expediter or Production Superintendent notifies the aircraft crew chief and maintenance technicians of any scheduled maintenance activities either during shift roll call, or by having them review the daily maintenance schedule. The crew chief or maintenance technician is responsible for obtaining the necessary tools, equipment, and parts from their support flight and, if necessary, supply. Once the job is complete, they should notify the expeditor and clear (sign-off) the write up in the aircraft forms and MMIS by indicating the maintenance actions taken.

Aircraft Scheduled for Next Mission

While the aircraft is undergoing corrective and preventive maintenance, it may be scheduled to fly its next mission. The flying requirement for a particular aircraft is documented in the monthly and weekly flying schedules. The production superintendent closely monitors these schedules to ensure the aircraft are ready for the next scheduled flying mission. As this time approaches, the maintainers prepare the aircraft for its mission and for flight.

Aircraft Mission Preparation

During this phase, many activities may occur simultaneously. Final corrective and preventive maintenance actions are completed; fuel adjustments are made to accommodate last-minute mission changes; munitions, chaff, ammunition, specialized pods, and specialized equipment are loaded and configured. The aircraft crew chief is responsible for ensuring the aircraft is ready for its mission. All these activities must be closely monitored and coordinated to ensure nothing is overlooked.

Pre-Launch Inspection

Pre-launch activities involve detailed maintenance and aircrew inspections. Brief explanations of the Pre-Flight and aircrew inspections follow. TO 00-20-5 contains a complete discussion of aircraft inspections.

Pre-Flight Inspection

A Pre-Flight Inspection is a flight preparedness check that the crew chief does in accordance with the aircraft. This inspection includes visually examining the aircraft and operationally checking certain systems and components to ensure there are no serious defects or malfunctions.

Aircrew Inspection

The aircrew accomplishes the aircrew inspection, commonly referred to as the "Dash one inspection," in accordance with the aircraft aircrew manual. This inspection includes a visual examination of the aircraft and may require the aircrew to configure certain systems in preparation for launch and mission.

Once the inspections are complete, the aircrew and maintainers carefully review aircraft forms to ensure all discrepancies are cleared. An exceptional release is required. This is the final check performed by maintenance before they release the aircraft to the aircrew.

Aircraft Launch

At this point, the aircrew starts the engines, powers up systems and makes final adjustments in preparation for launch. Maintainers disconnect and move the support equipment away from the aircraft. When cleared by the control tower, the crew chief marshals the aircraft out of its parking spot and onto the ramp or taxi way. Some aircraft require an End-of-Runway Inspection. The purpose of this inspection is to detect critical defects that may have developed or have become apparent during ground operation of the aircraft. It is performed immediately prior to take-off at a designated location usually near the end of the runway. Some units publish a local checklist for end-of-runway procedures.

Post-Launch Cleanup

Finally, after the aircraft is airborne, the maintainers clean up the parking location. Personnel must store all items such as the fire extinguisher, trash receptacle, tire chock, and inlet covers in their proper locations. A Foreign Object Damage (FOD) check should also occur to ensure someone removes objects that may have blown onto the parking spot during aircraft taxi.

Appendix 2: Exhaustive List of Performance Measures

Exhaustive List of Performance Measures				
		Measure Sources		
#	Performance Measure	9302	HOF Reports	Metrics Manual
1	12-Hour Fix Rate	Yes		Yes
2	12-Hour Fixes Completed	Yes		
3	4-Hour Fix Rate	Yes		Yes
4	4-Hour Fixes Completed	Yes		
5	8-Hour Fix Rate	Yes		Yes
6	8-Hour Fixes Completed	Yes		
7	Adherence to OPS/MXS Schedule			
8	Air Abort Rate	Yes		
9	Air Aborts	Yes		
10	Average Repair Time (Fighters)			
11	Average Repair Time (Other)			
12	Average Time as Hangar Queen			
13	Backup Aircraft Inventory (BAI)			Yes
14	Break Rate			Yes
15	Cannibalization Rate	Yes	Yes	Yes
16	Career Development Course Success Rate			Yes
17	Cat I Hangar Queens	Yes		
18	Cat II Hangar Queens	Yes		
19	Cat III Hangar Queens	Yes		
20	Chargeable Deviations			Yes
21	Code 3 Breaks	Yes		Yes

Exhaustive List of Performance Measures				
		Measure Sources		
#	Performance Measure	9302	HOF Reports	Metrics Manual
22	Could Not Duplicate Rate		Yes	
23	Deferred Discrepancies Leading to RR Instances			
24	Deferred Discrepancies Leading to TNMC or PMC			
25	Deferred Discrepancy Rate AWM		Yes	Yes
26	Deferred Discrepancy Rate AWP		Yes	Yes
27	Departure Reliability			
28	Depot Scheduling		Yes	
29	Discrepancies Awaiting Maintenance			
30	Discrepancies Awaiting Parts			
31	EEO Complaints			
32	Electronic Warfare Pod Mission-Capable Rate			
33	Functional Check Flight (FCF) Release Rate			Yes
34	Fix Rate			Yes
35	Flying Schedule Effectiveness	Yes		Yes
36	Fully Mission-Capable Rate			Yes
37	Ground Aborts	Yes		
38	Hourly Utilization Rate (UTE)			Yes
39	Hours Flown	Yes		
40	Hours Programmed	Yes		
41	IG Complaints			
42	Issue Effectiveness Rate			
43	Job Data Documentation Error Rate	Yes		
44	Judicial Punishments			

Exhaustive List of Performance Measures				
		Measure Sources		
#	Performance Measure	9302	HOF Reports	Metrics Manual
45	Maintenance Man-Hours per Flying Hour	Yes		
46	Maintenance Scheduling Effectiveness			Yes
47	Mean Time to Failure			
48	Mean Time to Repair			
49	Mission-Capable Rate	Yes	Yes	Yes
50	Mission-Impaired Capability Awaiting Parts			
51	Non-Chargeable Deviations			Yes
52	Non-Judicial Punishments			
53	Primary Aircraft Inventory (PAI)			Yes
54	Partially Mission-Capable Maintenance	Yes		Yes
55	Partially Mission-Capable Supply	Yes		Yes
56	Phase Average		Yes	Yes
57	Process Improvements			
58	Promotion Average			
59	Quarterly Annual Awards			
60	Repeat-Recur Rate			Yes
61	Scheduled Hours	Yes		
62	Sortie UTE			Yes
63	Sorties Flown	Yes		
64	Sorties Programmed	Yes		
65	Sorties Scheduled	Yes		
66	Spare Aircraft Inventory			
67	Special Experience Identifier			

Exhaustive List of Performance Measures				
		Measure Sources		
#	Performance Measure	9302	HOF Reports	Metrics Manual
68	Stockage Effectiveness Rate			Yes
69	Time Compliance Technical Orders Finished		Yes	
70	Total Abort Rate	Yes	Yes	Yes
71	Total Accumulated Cycles		Yes	
72	Total Aircraft Control Deviations	Yes		Yes
73	Total Deviations	Yes		Yes
74	Total Higher Command Deviations	Yes		Yes
75	Total Maintenance Deviations	Yes		
76	Total Operations Deviation	Yes		Yes
77	Total Repair Cycle Time			Yes
78	Total Supply Deviations	Yes		Yes
79	Total Weather Deviations	Yes		Yes
80	Totally Not Mission-Capable Maintenance	Yes	Yes	Yes
81	Totally Not Mission-Capable Supply	Yes	Yes	Yes
82	Training No-Shows			Yes
83	Training Overdues			Yes
84	Training Schedule Adherence			
85	Unit Average Skill Level			
86	Upgrade Training Status			Yes
87	Weather			

Appendix 3: Family to Measure Association

Family to Measure Association	
Family	Measure
Excellence	Air Abort Rate
	Air Aborts
	Break Rate
	Code 3 Breaks
	Could Not Duplicate Rate
	FCF Release Rate
	Job Data Documentation Error Rate
	Mean Time to Failure
	Mean Time to Repair
	Repeat Recur Rate
	Total Abort Rate
	Total Accumulated Cycles
Growth	Career Development Course Success Rate
	EEO Complaints
	IG Complaints
	Judicial Punishments
	Non-Judicial Punishments
	Process Improvements
	Promotion Average
	Quarterly Annual Awards
	Special Experience Identifier
	Training No-Shows
	Training Overdues

Family to Measure Association	
Family	Measure
	Training Schedule Adherence
	Unit Average Skill Level
	Upgrade Training Status
Productivity	Average Repair Time (Fighters)
	Average Repair Time (Other)
	Backup Aircraft Inventory
	Electronic Warfare Pod Mission-Capable Rate
	Fully Mission-Capable Rate
	Hours Flown
	Hours Programmed
	Maintenance Man-Hours per Flying Hour
	Mission-Capable Rate
	Primary Aircraft Inventory (PAI)
	Partially Mission-Capable Maintenance
	Sortie UTE
	Sorties Flown
	Sorties Programmed
	Totally Not Mission-Capable Maintenance
Scheduling	4-Hour Fix Rate
	8-Hour Fix Rate
	12-Hour Fix Rate
	Chargeable Deviations
	Depot Scheduling
	Fix Rate

Family to Measure Association	
Family	Measure
	Flying Schedule Effectiveness
	Hourly UTE
	Maintenance Scheduling Effectiveness
	Non-Chargeable Deviations
	Phase Average
	Scheduled Hours
	Sorties Scheduled
	Time Compliance Technical Orders Finished
	Total Aircraft Control Deviations
	Total Deviations
	Total Higher Command Deviations
	Total Operations Deviations
	Total Weather Deviations
	Weather
Supply	Average Time as Hangar Queen
	Cannibalization Rate
	Cat I Hangar Queens
	Cat II Hangar Queens
	Cat III Hangar Queens
	Discrepancies Awaiting Parts
	Issue Effectiveness Rate
	Mission-Impaired Capability Awaiting Parts Fill Rate
	Partially Mission-Capable Supply
	Spare Aircraft Inventory

Family to Measure Association	
Family	Measure
	Stockage Effectiveness Rate
	Total Supply Deviations
	Totally Not Mission-Capable Supply
Timeliness	4-Hour Fixes Completed
	8-Hour Fixes Completed
	12-Hour Fixes Completed
	Adherence to OPS/MXS Schedule
	Deferred Discrepancies Leading to RR Instances
	Deferred Discrepancies Leading to TNMC or PMC
	Deferred Discrepancy Rate AWM
	Deferred Discrepancy Rate AWP
	Departure Reliability
	Discrepancies Awaiting Maintenance
	Ground Aborts
	Total Maintenance Deviations
	Total Repair Cycle Time

Appendix 4: BSC Validation Questionnaire



UNIVERSITY OF ARKANSAS



In support of research to develop a "health-of-fleet" type metric, please rank the aircraft maintenance performance metrics below in order of decreasing criticality.

- 1) Rank each of the four Perspectives (categories) in order of decreasing criticality (1 = most critical)
- 2) Within each Perspective, add any critical metrics that we omitted
- 3) Rank all metrics within each Perspective in order of decreasing criticality (1 = most critical)

Mission Perspective (Rank ____)

- Long term ability to improve combat capability

- ___ Maintenance hours per flying hour
- ___ MC rate
- ___ PMCM
- ___ Sorties flown
- ___ TNMCM
- ___ _____
- ___ _____
- ___ _____

Influencing Factors Perspective (Rank ____)

- Success with collaborators and functional processes

- ___ CANN rate
- ___ MICAP fill rates
- ___ Maintenance Scheduling Effectiveness
- ___ TNMCS
- ___ _____
- ___ _____
- ___ _____

Management Perspective (Rank ____)

- Achievement of customer service

- ___ Adherence to OPS/MXS schedule
- ___ DD rate AWM
- ___ Total maintenance deviations
- ___ 4-hour fix rate
- ___ 8-hour fix rate
- ___ 12-hour fix rate
- ___ Days in Phase/ISO
- ___ _____
- ___ _____

Internal Enhancement Perspective (Rank ____)

- Necessity for innovation and growth

- ___ CND rate
- ___ Repeat-Recur (RR) rate
- ___ Special Experience Identifiers
- ___ Total abort rate
- ___ Training schedule adherence
- ___ Upgrade Training
- ___ Unit average technical skill level
- ___ _____
- ___ _____
- ___ _____

Please check all of the applicable boxes regarding your job description below for response categorization:

- | | |
|---|--|
| <input type="checkbox"/> Group-level mxs supervision/staff | <input type="checkbox"/> Flight Chief |
| <input type="checkbox"/> Squadron-level mxs supervision/staff | <input type="checkbox"/> Lead Technician |
| <input type="checkbox"/> Flight-level mxs supervision/staff | <input type="checkbox"/> Flightline Maintainer |
| <input type="checkbox"/> Production Supervisor | <input type="checkbox"/> Other _____ |
| <input type="checkbox"/> Expeditor | |

Appendix 5: Questionnaire—Raw Data Spreadsheet

Trial #	Perspectives — Rankings			
	Mission	Influencing Factors	Management	Internal Enhancement
1	1	3	2	4
2				
3	1	2	3	4
4	1	1	2	3
5	3	4	1	2
6	2	3	4	1
7	2	3	1	4
8	1	2	3	4
9				
10	1	2	3	4
11	1	3	2	4
12	2	4	3	1
13	1	3	2	4
14	1	3	2	4
15	4	3	1	2
16				
17	1	2	3	4
18	1	2	3	4
19	1	3	2	4
20	3	4	1	2
21	1	2	3	4
22	1	2	3	4
23	1	2	3	4
24	3	1	2	4
25				
26	1	4	2	3
27				
28	1	2	3	4
29	1	2	3	4
30	2	4	3	1
31	1	3	2	4
32	1	4	3	2
33	4	3	1	2
34				
35	1	4	3	2
36	2	4	1	3

[illegible]

Appendix 6: BSCol Functional Standards Brochure

Balanced Scorecard Functional Standards™ Release 1.0a

May 5, 2000

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Accelerate Time to Results

1.0 Background

Within the past few years the Balanced Scorecard has become a key tool for managing and implementing strategy in organizations. Responding to this business demand, many analytical application, ERP, and database vendors are developing and releasing software to support executive decision-making using the Balanced Scorecard methodology. This development of software-enabled Balanced Scorecards will inevitably lead to the implementation of Balanced Scorecards at an increasing number of organizations throughout the world. Central to the Balanced Scorecard methodology is holistic vision of a measurement system tied to the strategic direction of the firm. The Balanced Scorecard is based on strategic implementation through focus on four perspectives, with financial objectives and measures supported by customer, internal, and learning and growth objectives and metrics. By measuring and managing the business using this balanced set of measures, an organization can ensure rapid and effective implementation of strategy and facilitate organizational alignment and communication.

Many organizations are accelerating the benefits from their Balanced Scorecard by using enabling technology to facilitate their Balanced Scorecard management process. If an organization is to capture the full potential of the Balanced Scorecard management system, the enabling technology it implements should support the requirements of the desired management process. If the elements of the management process are not reflected in the application, the resulting process will be sub-optimal. Currently, many software vendors are offering applications that bear the name Balanced Scorecard. Some of these applications support a strategic management process, while others do not. This has made the Balanced Scorecard technology marketplace confusing for potential buyers.

To facilitate consistent and appropriate use of the Balanced Scorecard globally, a need has arisen for harmonization and standardization of the methodology of the Balanced Scorecard as envisioned by the creators of the concept, Dr. Robert Kaplan and Dr. David Norton. Therefore, Balanced Scorecard Collaborative, a global center of excellence on all things related to Balanced Scorecards, founded by Drs. Kaplan and Norton, has created Balanced Scorecard Functional Standards.

Balanced Scorecard Functional Standards identify user requirements and needs, based on the experience professionals from the Balanced Scorecard Collaborative have had with more than 300 clients. These observations have been codified in the functional standards to provide guidance for organizations preparing to purchase a Balanced Scorecard application and to provide a functional baseline for technology vendors developing a Balanced Scorecard application. These standards should be viewed as a minimum threshold upon which vendors will innovate to meet any additional requirements of their market.

The purpose of this document is to provide an overview of Balanced Scorecard Functional Standards.

2.0 Document References

The functional standards listed below are based on the published methodology of Drs. Kaplan and Norton and the expertise of the staff of Balanced Scorecard Collaborative. For more information about the methodology behind the standards, and the best-in-class application of Balanced Scorecard methodology, please refer to the following documents:

"Linking the Balanced Scorecard to Strategy" in *California Management Review*, by Robert S. Kaplan and David P. Norton, October 1996.

Abstract: The Balanced Scorecard was developed to measure both current operating performance and the drivers of future performance. Many managers believe they are using a Balanced Scorecard when they supplement traditional financial measures with generic, non-financial measures about customers, processes, and employees. But the best

Balanced Scorecards are more than ad hoc collections of financial and non-financial measures. The objectives and measures on a Balanced Scorecard should be derived from the business unit's strategy. A scorecard should contain outcome measures and the performance drivers of those outcomes, linked together in cause-and-effect relationships.

Balanced Scorecard: Translating Strategy into Action, by Robert S. Kaplan and David P. Norton (Harvard Business School Press, 1996).

Abstract: The Balanced Scorecard translates a company's vision and strategy into a coherent set of performance measures. The four perspectives of the scorecard—financial measures, customer knowledge, internal business processes, and learning and growth—offer a balance between short-term and long-term objectives, between outcomes desired and performance drivers of those outcomes, and between hard objective measures and softer, more subjective measures. In the first part, Kaplan and Norton provide the theoretical foundations for the Balanced Scorecard; in the second part, they describe the steps organizations must take to build their own Scorecards; and, finally, they discuss how the Balanced Scorecard can be used as a driver of change.

"Using the Balanced Scorecard as a Strategic Management System" in *Harvard Business Review*, by Robert S. Kaplan and David P. Norton, January 1996.

Abstract: As companies transform themselves to compete in the world of information, their ability to exploit intangible assets is becoming more decisive than their ability to manage physical assets. Several years ago, Robert S. Kaplan and David P. Norton introduced the balanced scorecard, which enabled companies to track financial results while monitoring progress in building the capabilities they would need for growth. Recently, some companies have gone further and discovered the scorecard's value as the cornerstone of a new strategic management system. Traditional management systems rely on financial measures, which bear little relation to progress in achieving long-term strategic objectives. The scorecard introduces four new processes that help companies connect long-term objectives with short-term actions.

"Putting the Balanced Scorecard to Work" in *Harvard Business Review* by Robert S. Kaplan and David P. Norton, September 1993.

Abstract: In an earlier, groundbreaking article, "Balanced Scorecard—Measures That Drive Performance", the authors proposed a new measurement system that provided managers with a comprehensive framework to translate a company's strategic objectives into a coherent set of performance measures. Now the authors show how several companies are putting the balanced scorecard to work. Effective measurement, the authors point out, must be an integral part of the management process. Much more than a measurement exercise, the balanced scorecard is a management system that can motivate breakthrough improvements in such critical areas as product, process, customer, and market development. Several examples—Rockwater, Apple Computer, and Advanced Micro Devices—illustrate how the scorecard combines measurement and management in different companies. From the experiences of these companies and others, the authors have found that the balanced scorecard is most successful when it is used to drive the process of change.

"The Balanced Scorecard: Measures That Drive Performance" in *Harvard Business Review* by Robert S. Kaplan and David P. Norton, January 1992.

Abstract: During a year-long research project, the authors developed a "balanced scorecard" performance measurement system that allows executives to view a company from several perspectives simultaneously. The scorecard includes financial measures that reveal the results of actions already taken, as well as three sets of operational measures that show customer satisfaction, internal processes, and the organization's ability to learn and improve. Creating a balanced scorecard requires translating a company's strategy and mission statement into specific goals and measures. Managers then track those measures as they work toward their goals.

3.0 Definitions

For the purpose of this document, the following definitions apply:

Balanced Scorecard is a multi-dimensional framework created by Dr. Robert Kaplan and Dr. David Norton that uses measurement to describe an organization's strategy (see references in Section 2.0).

Balanced Scorecard Application refers to any software package which uses the methodology of Drs. Norton and Kaplan to facilitate strategic decision-making using the Balanced Scorecard methodology, or any package which uses the term "Balanced Scorecard" in its marketing material, title, or external communications.

Standards as defined in this document refer only to the functionality of the software package as it relates to the Balanced Scorecard methodology. This standard does not specify any technology solutions, refer to scalability of the solution, or discuss interconnectivity of the package with other systems.

Balanced Scorecard Methodology refers, in the context of these standards, to the Balanced Scorecard methodology as initially defined by Drs. Kaplan and Norton and as currently practiced by Balanced Scorecard Collaborative. The methodology is under continual development, and the standards will evolve to reflect current best practices and thought leadership in the Balanced Scorecard concept.

4.0 Balanced Scorecard Collaborative

Balanced Scorecard Collaborative, Inc. facilitates the worldwide awareness, use, enhancement, and integrity of the Balanced Scorecard as a value-added management process. The Collaborative offers a variety of education, training, research, and development services designed to share best practices to achieve best results. Founded and managed by Balanced Scorecard creators Drs. Robert Kaplan and David Norton, the Collaborative provides organizations and individuals with a global center of excellence and expertise on all things related to Balanced Scorecards.

5.0 Basic Functional Requirements for Balanced Scorecard Applications

Balanced Scorecard applications must be able to facilitate management of the organization through the Balanced Scorecard methodology as documented in the literature above and as practiced by Balanced Scorecard Collaborative. The standards as outlined below represent the minimum functionality for a Balanced Scorecard system. Software providers are encouraged to differentiate their products beyond the minimum standards outlined below. The standards documentation has been divided into four sections:

Balanced Scorecard Design (Section 5.1)

The application should be able to flexibly accommodate the basic elements of a proper Balanced Scorecard design. The application must be able to (1) view the strategy from four perspectives (financial, customer, internal, and learning), (2) identify strategic objectives for each perspective, (3) associate measures with strategic objectives, (4) link strategic objectives in cause and effect relationships, (5) assign targets to measures, and (6) list strategic initiatives.

Strategic Education and Communication (Section 5.2)

One of the key reasons for implementing a Balanced Scorecard software solution is the facilitation of strategic education and communication. Therefore, a certified application will enable users to document and communicate descriptions of objectives, measures, targets, and initiatives aligned with the strategy.

Business Execution (Section 5.3)

Initiatives (discretionary investment programs) are the testing grounds for the strategy expressed in the Balanced Scorecard. Therefore, a certified application must make explicit the relationship between initiatives required to achieve the strategy and the associated strategic objective.

Feedback and Learning (Section 5.4)

Through proper system design, the feedback cycle time for management information can be significantly reduced. Analysis of the measure results against targets will allow managers to understand which areas of the organization require further attention. However, the system should not override the judgment of a senior executive – the Balanced Scorecard system should rely on both objective and subjective judgments, as well as graphical indicators, to report on progress of a particular measure against its target. These design principles are outlined in greater detail in the text that follows.

As of September 30, 1999, Balanced Scorecard Collaborative considers these the minimum functional standards that a Balanced Scorecard application should have in order to reflect the methodology endorsed by Balanced Scorecard Collaborative. Release 1.0a, published on May 5, 2000 includes minor modifications that do not affect the substance of the functional standards.

5.1 Balanced Scorecard Design

A certified Balanced Scorecard application will accommodate the basic elements of a proper Balanced Scorecard design. Naming conventions may differ, but the design structure of certified applications must include the following six features: (see Figure 1, Basic Balanced Scorecard Design, for an example)

1. Perspectives

A perspective is a component into which the strategy is decomposed to drive implementation. Typically, there are four perspectives; financial, customer, internal and learning and growth. Others may be added or replace these based on a specific strategic need. A perspective is a major element of the strategy often representing a stakeholder category or point of view. Certified applications will include at least four basic perspectives (financial, customer, internal processes, learning and growth) and have the ability to rename perspectives at the user's option.

2. Objectives

An objective is a statement of strategic intent. An objective states how a strategy will be made operational. Generally, the objectives form the building blocks for the overall strategy of the organization. Certified applications will allow strategic objectives to be aligned with at least one perspective.

3. Measures

A measure is a performance metric that will reflect progress against an objective. A measure must be quantifiable. The measures communicate the specific behavior required to achieve the objective and become the actionable statement of how the strategic objective will be accomplished. Leading measures are predictors of future performance, while lagging measures are outcomes. A certified application will allow a reasonable number of measures explicitly linked to at least one objective.

4. Targets

A target is a quantifiable goal for each measure. The set of targets found on the Balanced Scorecard become the overall goals of the organization. Targets create opportunity to succeed, help the organization monitor progress toward strategic goals, and communicate expectations. A certified application will allow quantifiable targets with a specified timeframe.

5. Cause and Effect Linkages

Objectives are related to one another through cause and effect relationships. The cause and effect linkages are similar to "if-then" statements. For example, *if* an airline decreases the on-ground turn-around time (objective 1), *then* the airline will require fewer planes (objective 2) *and* customers will be more satisfied with on-time take off (objective 3) and corporate profitability will increase (objective 4). These cause and effect linkages should be explicit. A certified application will allow objectives to be linked and graphically represented on-screen as a series of cause and effect linkages (strategy map). The linkages should be able to be easily changed and edited as appropriate.

6. Strategic Initiatives

Strategic initiatives are those action programs (discretionary investments or projects) that drive strategic performance. These are the activities that groups will focus on to ensure attainment of strategic results. All initiatives underway in an organization should be aligned with the strategy in the Balanced Scorecard. A compliant package will allow for a set of strategic initiatives to be linked to at least one objective.

5.2 Strategic Education and Communication

Certified applications must include the following functionality:

Base Level Descriptors

The six key elements of the Balanced Scorecard (perspectives, objectives, measures, targets, linkages and initiatives) are typically defined in greater levels of detail. For instance, *objectives* may be further defined through a sentence or two describing the strategic situation or issue. *Measures and targets* are typically broken down into formulas, units of measure, frequency of reporting, target owner, reporting responsibility, data sources, target effective date, and target history. *Initiatives* also require greater description such as timeline, resources, budget, benefits, and risks. Such documentation is important to users to ensure consistency and repeatability of reporting and to capture the strategic intent of each element. Certified applications will facilitate the documentation of qualitative descriptions of each element of the Balanced Scorecard.

5.3 Business Execution

Link of Initiatives to Objectives

Strategic initiatives are the base elements of work that drive strategic change. They are the discretionary programs such as training, advertising, reengineering and others that are put in place to make the strategy happen. They must be monitored on a continuous basis to insure that they are being implemented as planned and producing the desired results. A strategic initiative should be explicitly linked or mapped to achieving one or more strategic objective. Certified applications should be able to display matching initiatives and objectives and should allow initiatives to be tied to more than one strategic objectives. (Reference Figure 1 for example)

5.4 Feedback and Learning

Base Level Reporting

Base level reporting includes reporting of performance data for each measure. Historical performance against targets and multiple reporting views are desirable features. Certified applications should be able to display current performance data for each measure.

Subjective Performance Assessments

The decision whether or not a measure is on track for meeting a target must ultimately be made by a manager who can subjectively analyze the data. The subjective performance assessments should also be backed up by a memo-style qualitative assessment of the external or internal variables underlying the assessment. Certified applications will

permit subjective assessments of performance (e.g., red, yellow, green) as well as memo-style qualitative descriptions of performance.

Visual Status Indicators

Each element of the scorecard must have a visual indicator of performance status, e.g., green or a plus sign if a measure or objective is on plan, red or a minus sign if behind plan. Certified applications will graphically display performance against targets in an easy-to-comprehend format, and will allow for modification to suit individual end-user needs.

6.0 Conclusion

It is anticipated that by following these guidelines software developers will be able to develop Balanced Scorecard applications, which enable users to capture the benefit of the Balanced Scorecard management system. Buyers of Balanced Scorecard applications will also benefit, as they will be able to leverage the expertise of Balanced Scorecard Collaborative and numerous successful organizations, as expressed in these standards, to select appropriate Balanced Scorecard software that will meet their needs.

Figure 1: Basic Scorecard Design (Example)

Perspective	Cause & Effect Linkage	Objectives	Measures	Targets	Initiatives
Financial		<ul style="list-style-type: none"> • Profitable Business Growth 	<ul style="list-style-type: none"> • Operating Income • Sales vs. Last Yr 	<ul style="list-style-type: none"> • 20% Increase • 12% Increase 	<ul style="list-style-type: none"> • Likos Program
Customer		<ul style="list-style-type: none"> • Quality Product from a Knowledgeable Associate 	<ul style="list-style-type: none"> • Return Rate • Customer Loyalty <ul style="list-style-type: none"> – Ever Active % – # units 	<ul style="list-style-type: none"> • Reduce by 50% each yr • 60% • 2.4 units 	<ul style="list-style-type: none"> • Quality management program • Customer loyalty program
Internal Process		<ul style="list-style-type: none"> • Improve factory quality 	<ul style="list-style-type: none"> • % of Merchandise from "A" factories • Items in-Stock vs. Plan 	<ul style="list-style-type: none"> • 70% by year 3 • 85% 	<ul style="list-style-type: none"> • Corporate Factory Development Program
Learning & Growth		<ul style="list-style-type: none"> • Train & equip the workforce 	<ul style="list-style-type: none"> • % of Strategic Skills Available 	<ul style="list-style-type: none"> • yr 1 50% • yr 3 75% • yr 5 90% 	<ul style="list-style-type: none"> • Strategic Skills Plan • Merchants Desktop

Appendix 7: Contact Information for Software Packages

Active Strategy

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